

PLEXUS ORIENTED ELECTRICITY BILL SURVEILLANCE SYSTEM



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DECLARATION

We, hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researchers are mentioned by reference. This thesis, neither in whole or in part, has been previously submitted for any degree.

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ABSTRACT

Neoteric Bangladesh has indeed come up with digital electric meter but retrieving the data is still antiquated and is still not maintained by anyone in Bangladesh. Our team is trying to come up with a solution where not only the power supply company can retrieve the data via an automated system but also the end user can view it. Our objective is minimizing the delay of real time data retrieval and ensuring a secured channel of data transfer, while our main challenge is to read the data from a government authorized digital electric meter. It will be indeed a good thing for everyone as it will save the time of a lot of people which can make a huge impact all over Bangladesh. The application will be available in web format and also will be applicable for android users who can easily download our application and use it easily using internet or Wi-Fi. Not only it will show the bills that are pending but also it will calculate the bills every second making it easier for people to see the units.

ACKNOWLEDGEMENT

The main core idea of the thesis came to the mind of Dr.Amitabha Chakrabarty (Assistant Professor), Department of Computer Science and Engineering, BRAC University, Dhaka. He thought we will be capable enough to carry out the thesis successfully. The work is conducted by Hasnine Wafiq, Mohannad Zoha and Md.Moneruzzaman Manik. It has been a long ride for us and we are done with our work. Each and everyone in our group has participated and contributed with their utmost best effort which is phenomenal and we would like to thank them all.

Most importantly we would like to thank our supervisor Dr. Amitabha Chakrabarty. He has been there through out to push us to complete our work in time and make an astonishing paper. As the main thesis idea was proposed and realized by Dr. Amitabha Chakrabarty, we are grateful to him that we got the chance to work under his supervision. Without his motivation and inspiration it would not have been possible.

Moreover, there are other people that are needed to be thanked are our class mates who supported us always with everything.

But, family is someone who was there always and has done everything they could to make it happen with the financial support. Our project started with trial and error so we did require a lot of instruments and gadgets to successfully complete our thesis. A very big thank you to our friends and family who constantly provided us with whatever we needed.

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LIST OF ABBREVIATIONS

AC	Alternating Current
ADC	Analog to Digital Conversion
ADT	Android Development Tool
AES	Advances Encryption Search
CLI	Command line Interface
CSS	Cascading Style Sheets
CT	current transformer
DC	Direct Current
GPRS	General Packet Radio Service
HTML	Hypertext Markup Language
ICSP	In circuit Serial Programming
IDE	Integrated Development Environment
IOS	iphone Operating System
JDK	Java Development Kit
JS	JavaScript
JVM	Java Virtual Machine
LCD	Liquid Crystal Display
MCP	Micro- chip
MCU	Microcontroller Unit
MySql	Structured query Language
PCB	Process Control Block
PHP	Personal Home Page
RMS	Root Mean Square
SD	Secure Digital
SPI	Serial Port Interface
USB	Universal Serial Bus

Chapter 1

INTRODUCTION

In the field of engineering of Bangladesh it has been seen that electric meter has not been that advanced. Verification of consumer electricity meters with conventional methods is costly and inefficient [1]. Hence, the development is becoming necessary in every aspects of the world, so we must progress further in the reading of absolute data from an electric meter which is reasonable and easy to use.

It has been seen that other countries has implemented this type of work but not yet deployed in our country as the procedure is a bit challenging. Utility companies (electricity, gas, and water suppliers), governments, and researchers have been urging to deploy communication-based systems to read meters, known as automatic meter reading (AMR) [2].

Reading data from an electric meter has been a tough job in every aspects of our country. To overcome the problems of traditional electricity meters, Smart Meters have been upgraded and developed. With the use of Smart Meter data, energy alerts will be provided to the consumers based on hourly utilization of energy [3].

One of the researcher mentioned “The electricity market can be restructured with the installation of these meters, as it not only preserves the energy, but also reduces carbon dioxide emissions” [4]. In simple words it can be easily installed in apartments and buildings which is indeed a less time consuming process and also causes less CO₂ emissions. Moreover, the amount of bill that is generated can be seen in the web application and mobile application hence the chances of making a duplicated decreases.

Such concepts made live to our model. We used a lot of hardware tools and software methods to come up with the possible solution which is thought to be light weight model.

1.1 Motivation

It has been a tough job to come up with a suitable and cost effective solution as the entire work was very complex and huge. The tremendous amount of advancing technology in the electrical side has made us curious that we have to come up with a cost effective and advanced solution using the electric meter to read data and calculate the bills in units every second. The challenge was to simplify as much as possible which was indeed the core motivation for us.

Around the world it has been seen that development of technology now a days the automation in every field is becoming necessary. Further study on the papers that we have read made us more interested to work in this different type of project.

1.2 Scope of the Thesis

The thesis work deals with the energy that has been consumed from the digital electricity meter. The charm of our system is that the customer or users can view their billing status at any time which will be updated every second where it will be easier for them to track down their bills. Every month it generates a bill which will be calculated in our system for them hence making it easier for people and there will be less chance for the meter people to manipulate the bills. However, we have examined on daily basis that if it calculates the real value or not.

1.3 Features of Our System:

Our System will have some powerful features for the users and also the admin. So we broke it into two views, the first is the user view and the second one is admin panel. From User's perspective: He/she can register by accessing our website or maybe downloading our mobile application that will be available for windows, android and IOS versions. After registering they can login and have the all the things they want to check for. He/she can check status of present/past month. We will make a bulletin board news where the admin can update the status of the meter reading every now or then. Then if a user has some pending bill issues it will be notified there. Next is the admin panel which is the most important one. The admin can search users for e.g. after a user registers it will be notified to the admin. They will have the power to update the status of the user where the reading of the meter will be updated time to time. If bill is due as mentioned earlier the admin can warn the users by sending messages to him/her. The below table shows each of the perspectives:

User's Perspective	Administrator's Perspective
He or She can register via website or Smart Phone.	Populate the database and Search.
Can check bill status.	Update Bill status.
Bulletin Board for important Information.	Can keep track of user record.
Comment Box	Send Notification and update comments.
Mobile Apps for iOS, Android and Windows	Web Interface for controlling.

Table 1.4: Features of the system

1.4 Objectives

In our thesis the main objectives are listed as follows:

- **Minimizing delay of data transmission-** It has been seen that many of the data transmission requires time but we have overcome it and made our system as delay-less as possible.
- **Secured channel of data retrieval-** we made our best so that there will be no tampering of data
- **Mobile Application-** For the entire project we made a mobile application for the iOS, android and windows user where anywhere any people can download and use it.
- **Web based solution-** Plexus has been created as a web based solution where we will provide the users with the best possible way to sign up and sign in the easiest possible way where they can see their bills, comment.

Thesis Outline

Chapter 1 is the formal introduction of the thesis. We have discussed our motivation, scope, features and objectives.

Chapter 2 is the background study that covers the literature review of the work process from where we got the general ideas and discussions.

Chapter 3 focuses on the Specifications that include the hardware specification part, the software specification, the safe sequence and calibration. This entire chapter includes the necessary things we used to complete the project.

Chapter 4 is the proposed work part where we have explained our acquired results following our approach towards proposed work. Over here we mainly attached the workflow of our process, the use case diagram of our system with specifications, the schema diagram, ER diagram, Pseudo codes.

In chapter 5, it is the main system architecture of our thesis project.

In chapter 6, we have talked about the result and analysis part which includes cost estimation, website analysis, mobile app analysis and hardware calibration analysis.

In chapter 7, it mentions about the conclusion and the future aspects of our thesis project.

In chapter 8, the references are cited of which we made use of.

Chapter 2

LITERATURE REVIEW

While discussing and planning for our entire thesis we had to go through several papers to make it possible as it was very much challenging for us to complete the job. Kulkarni and Chaphekar discusses in their journal that day by day the household electrical energy is becoming important for our lives and it is becoming difficult to monitor energy in today's life [12]. Using other conventional methods is very much costly and is not indeed an efficient process [1]. This was the main motivation of our work and we thought that we will make it possible. He worked with the single phase metering IC which we thought will be useful for our project but we came up with another solution and it gave us an appropriate idea of how to complete the project smoothly. Khalifa, Naik and Nayak mentioned in their paper that technology of a smart meter is advanced and it will automatically update and send commands to the meters [2]. In this paper we get to know about the whole communication technology where it had the survey of where the communication technologies are used and the pros and cons of them. As our system is completely live in website and mobile application, this paper gave us the general idea of wireless communication. Moreover, we made an entire electric meter which made it wiser.

Tanvir on the other hand mentioned in his paper, that it is a very expensive task for energy meter reading where the meter reader goes to every house and checks the meter reading and bills them manually which is a slow process [5]. They carried out the work and found out different problems in the present system. This made us more conscious about our work and we decided to make it as much cost effective as possible so that everyone can use it. Again Tanvir mentioned that the data that is analog must be converted to digital (0 or 1) [5]. The challenge was to get reading from the analog digital watt meter.

We had no idea of what hardware to use in order to do communication. Chunjuan in his journal mentioned about the data's received are large and must be perceived from the remote meters [6] where the command is issued by GPRS. Reading this gave us an idea of using GPRS but it was a bit hazy and we planned to use Raspberry Pi instead which made the process smooth and faster and we thought it was more convenient for us to go with raspberry pi and it was a success. Hence our process is efficient and more secured.

According to Julius [13] proposed in his model that the mobile communication based smart metering will have lots of positive benefits like:

1. Very few cost/ cost effective.
2. Specific information
3. Exceptional Reliability
4. Real time

In his thesis he mentioned that it is difficult for people to pay bills that are far from the customers so we came up with both website and mobile application data where people will be able to sign up with their meter number (otherwise they will not be able to sign up) and can easily access to their billing status. We believe we have made our system very much user friendly for the customers which are indeed a positive sign.

Most Importantly Ross [19] in his paper clearly mentioned about the security purpose which is indeed very much necessary for the purpose of digital electricity billing process, he made few points:

- 1) Frauds may be there who will try to give false readings.
- 2) Must provide extensive security to private users.

However, we made our system to be very much secured and used AES where other hackers or frauds cannot hack or manipulate our data.

We compared all the papers and journals which actually helped us figure out the necessary needs that were need to be done to complete it with improving background and very much new to the country Bangladesh.

Chapter 3

SPECIFICATIONS

In this chapter we have discussed about hardware specification and the components we have used for our thesis project. Moving on, we have software specification where we have said what software we used to make our system. Later, a section about safety procedures and calibration between hardware and software are explained.

3.1 Hardware Specifications

In our Plexus Oriented Electricity Bill Surveillance System we have used lot of hardware components to make the entire system up and running properly. We implemented only the suitable and convenient components from a huge list of hardware. Breadboard, Vero board, Variac, Digital Clamp Meter, Step Down Transformer, Arduino Mega, Raspberry Pi, Current Transformers are some of them.

3.1.1 Breadboard

Breadboards are really effective to design circuits. It offers solder less connection that helps to change the components very quickly. We can see everything at a quick glance and it is very useful to troubleshoot problems as well. [22]. In our electricity bill surveillance system we have used the breadboard to design circuits accordingly to get the jobs done. Prototyping is the process of testing out an initial idea from which a robust idea is developed and it is one of the major advantages of using a breadboard. It was really easy for us to change the circuits randomly with the help of a breadboard. [23]

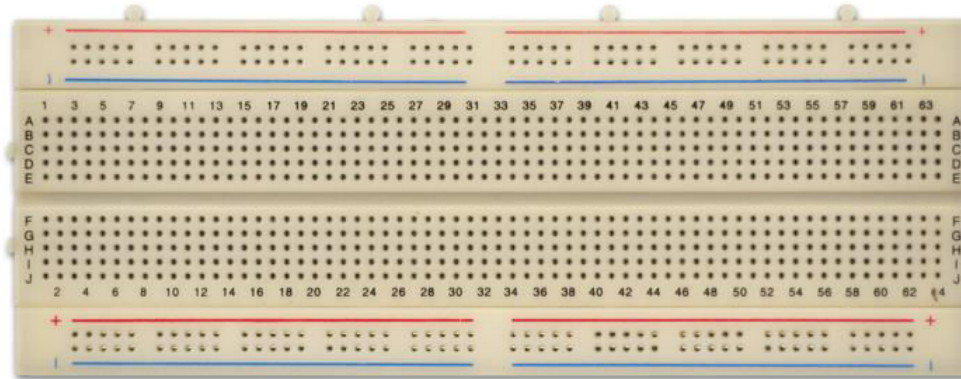


Figure 3.1.1: Breadboard

3.1.2 Vero board

Vero board is very essential to solder components permanently on the board. In case of any sensitive connection we use Vero board to make it solid. In this project, we had to use a Vero board to get a connection from breadboard to the arduino mega. We can ensure that there won't be any shaking after soldering it into the Vero board. It is small and very helpful to set a solid connection.

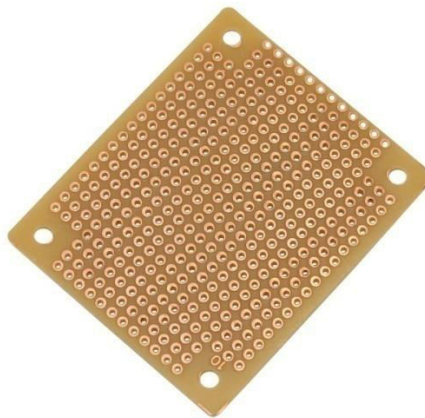


Figure 3.1.2: Vero Board

The cost of a Vero board is significantly less than PCB's. [24] It is very easy to modify a circuit on Vero board and make it smooth to run a project. It allows making a more permanent circuit which has more reliable connections than with breadboard without the expense of printed PCBs. It consists of strips of metal on a side of a board and a grid of holes which allows us to solder most types of non-surface mount ICs, resistors, capacitors onto them.

3.1.3 Variac

Variac is the trademark name of a variable autotransformer. Variac transformers are AC voltage controls that provide a variable AC voltage. Variac is used in test purpose for our electricity bill surveillance system. We can increase and decrease the voltage in the variac that helps us to figure out whether our meter shows the accurate result or not. Its distortion free output is very effective for sensitive electronic applications. [25]



Figure 3.1.3: Variac

Variable autotransformers automatically regulate voltages for industrial equipment, simulate power line conditions, and control switches that are dependent on external events. In real life, the voltage can go up at any time or can go down as well so in order to determine the actual result

we need to test the fluctuation of the voltage properly. Variac's are equipped with automatic switchgear in order to automatically step a voltage up or down, depending on preset conditions.

3.1.4 Digital Clamp Meter

Digital clamp meter are really helpful to calibrate our meter with the current. The biggest advantage of using a clamp meter is that we are able to measure the electric current that passes through a device without the need of breaking any circuits. It is important to make sure that the electric current is in the right range.



Figure 3.1.4: Digital Clamp Meter

When we have an electricity bill surveillance system that is filled with all sorts of different connections then we count on electricity and on them working properly. Now, if there is a fluctuation in electric current and the intensity is too much for one of the machines to stand it then we will not get the right result. [26] Therefore, in order to do the calibration properly we need this digital clamp meter.

3.1.5 Step down Transformer

Step down transformers are designed to reduce electrical voltage. Generally, the primary voltage is greater than the secondary voltage. For instance, in our project we need to reduce the voltage from 220v to 12v to pass it through our electric meter.[35] If we cannot reduce the voltage then it will burn the entire meter. In this scenario, we used step down transfer to reduce the voltage properly to continue our work properly.



Figure 3.1.5: Step down Transformer

Step down transformers convert electrical voltage from one level or phase configuration usually down to a lower level. It typically relies on the principle of magnetic induction between coils to convert voltage levels. The turn's ration of the coils determines the amount voltage transformation.

3.1.6 Arduino Mega

The Arduino Mega is the main controller in our plexus oriented electricity bill surveillance system. The Mega 2560 is a microcontroller board based on the ATmega2560. [27] It has 54 digital input/output pins all together of which 16 pins act as an analog inputs, 4 hardware serial ports, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller to connect with a computer or a AC-to-DC adapter to get started.

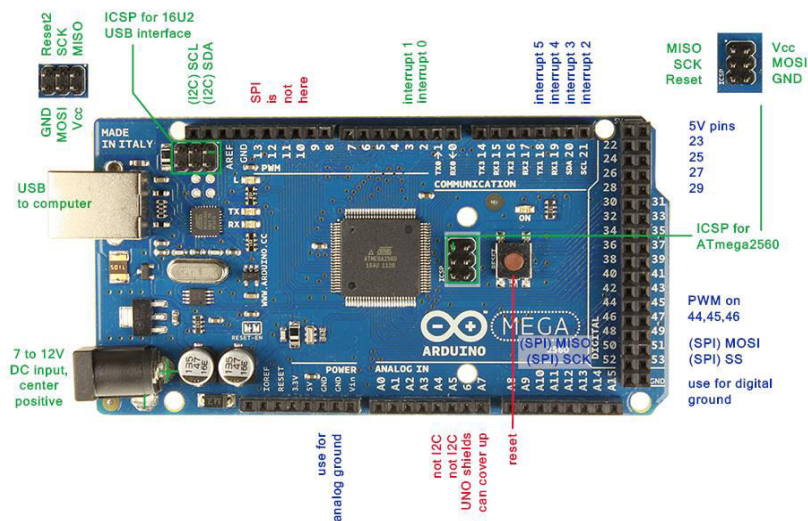


Figure 3.1.6: Arduino Mega

Each of the 54 digital pins on the Mega can be used as an input or output, using [pinMode\(\)](#), [digitalWrite\(\)](#), and [digitalRead\(\)](#) functions. They operate at 5 volts. To get the connection of our arduino mega we have used direct AC -to- DCadapter. Also, we kept 2 batteries in stock if there is any power failure to back it up. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. We have downloaded the Arduino software to work our Arduino Mega.

3.1.7 Raspberry Pi

We have used the raspberry pi for establishing connection with the arduino mega to our server. Raspberry Pi has the ability to interact with the outside world which was needed for our project. We are using a server to store data from the meter so we need this raspberry pi to collect data from the arduino mega and forward it to the server.

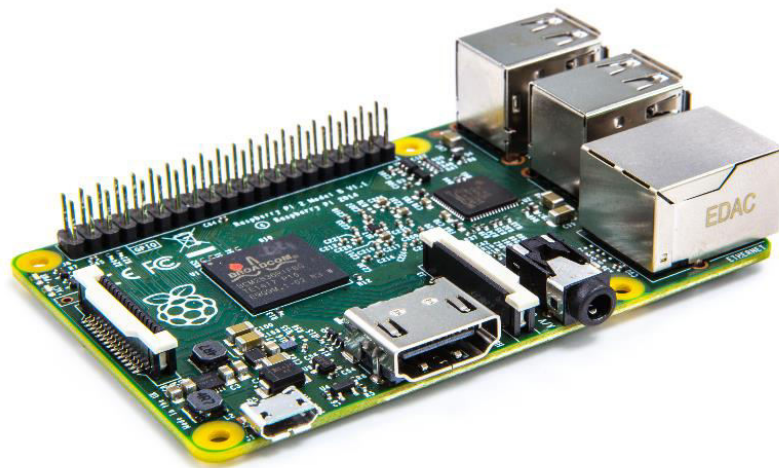


Figure 3.1.7: Raspberry Pi

The raspberry pi uses an SD card for storage which is fast and no moving parts. [28] This is portable and really handy for any sort of work. There are several status lights on the motherboard that give us the current status of the pi. Another advantage of using a raspberry pi is it has a huge community support. Support can be obtained quite easily for the hardware and software that runs on the Pi at any time.

3.1.8 LCD display

In order to display any numbers and basic letters 7 segment LCD Displays are the best option. Many times solutions need to display basic information such as weight, time, rate etc which does not require any type of graphics.[29] Similarly, in our electricity bill surveillance system we just need to display the volts, current, watt and w/h through a display. So, we have used the LCD display that gets the data straight from the arduino mega and display it on the LCD panel. It keeps the information really simple and quick to read.



Figure 3.1.8: LCD Display

In our 16x2 LCD Display we have mentioned about Voltage (V), Ampere (A), Wattage/hour (W/h) and the unit represented as (U). In figure (3.3.4) we can see a real figure of our 16x2 LCD Display where the above mentioned things are clearly mentioned.

3.1.9 Resistors

A Resistor is a passive two terminal electric component that implements electrical components as a circuit element. Resistors are used for multiple purposes like voltage drop, voltage divider, reduce current flow, and adjust signal levels etc. resistors are very cheap and easy to replace. A small low value resistor can be used instead of a more expensive fuse. In parallel connection, electric current is divided through the electrical gadgets. We can also use desirable electrical appliances at any time. The total resistance is very low, it is helpful when each component has different resistance and requires different current to work properly. [30] The electrical function of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance will fall within a manufacturing tolerance.



Figure 3.1.9: Resistors

3.1.10 Connectors

In our project we have used male to male, female to female and male to female connectors to connect multiple wires. It's very handy to connect multiple wires when we work on a large project. In the breadboard, Vero board we had to connect a lot of wires from different components so we had to use those different types of connectors to make the surveillance system up and running properly.

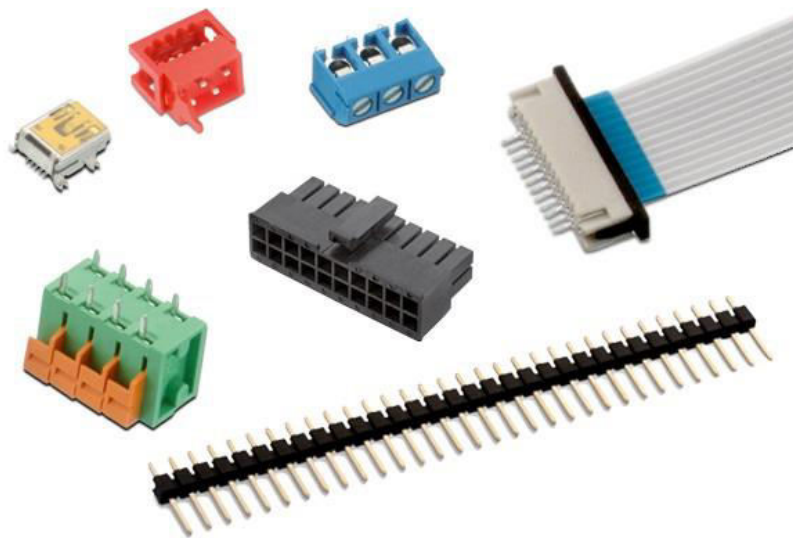


Figure 3.1.10: Connectors

In computing, an electrical connector can also be known as a physical interface (compare physical layer in OSI model of networking). Cable glands, known as cable connectors in the US, connect wires to devices mechanically rather than electrically and are distinct from quick-disconnects performing the latter.

3.1.11 Rectifier Diode

A rectifier is responsible for converting alternating current (AC) to direct current (DC). It is basically an electrical device composed of one or more diodes that converts AC to DC. A diode is like a one-way valve that allows an electrical current to flow in only one direction. This process called rectification. A rectifier can take the shape of several different physical forms such as solid-state diodes, vacuum tube diodes, mercury arc valves, silicon-controlled rectifiers and various other silicon-based semiconductor switches. [31]



Figure 3.1.11: Rectifier Diode

A rectifier diode lets electrical current flow in only one direction and is mainly used for power supply operation. Rectifier diodes can handle higher current flow than regular diodes and are generally used in order to change alternating current into direct current. They are designed as discrete components or as integrated circuits and are usually fabricated from silicon and characterized by a fairly large P-N-junction surface.

3.1.12 Capacitors

A capacitor is basically used to purify the voltage. A capacitor is a passive electronic component that stores energy in the form of an electrostatic field. Generally, a capacitor consists of two conducting plates separated by an insulating material called the dielectric. In our electricity bill surveillance system we have used 104 pf, 470 uf and 100 uf capacitors. The capacitance is directly proportional to the surface areas of the plates, and is inversely proportional to the separation between the plates. Capacitance also depends on the dielectric constant of the substance separating the plates. [32]

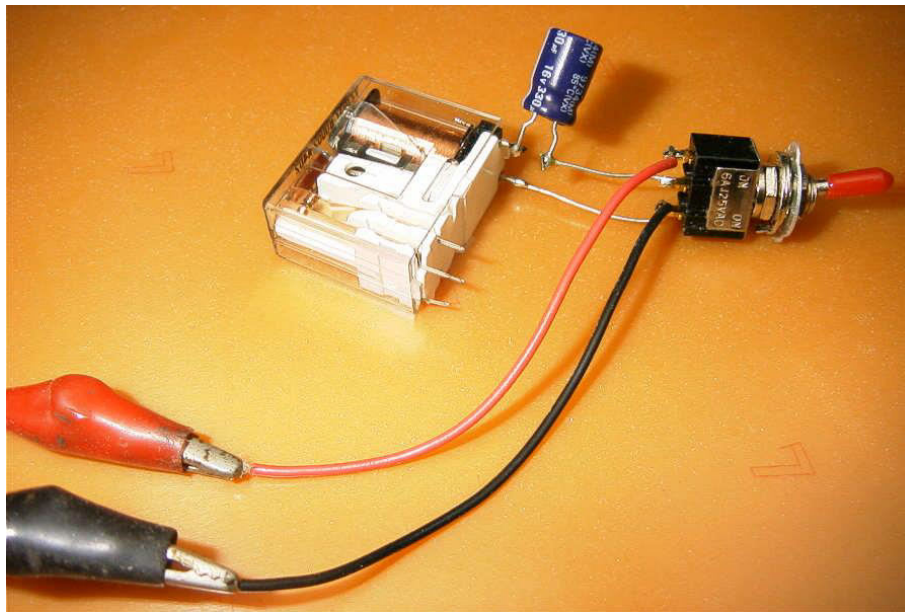


Figure 3.1.12: Capacitors

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge $+Q$ to collect on one plate and negative charge $-Q$ to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.

3.1.13 Current Transformer

The Current Transformer (C.T.) is basically a type of instrument transformer that is responsible to generate voltage depending on the load. This is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary. *Current transformers* reduce high voltage currents to a much lower value and provide a convenient way of safely monitoring the actual electrical current flowing in an AC transmission line using a standard ammeter. The principle of operation of a current transformer is no different from that of an ordinary transformer.

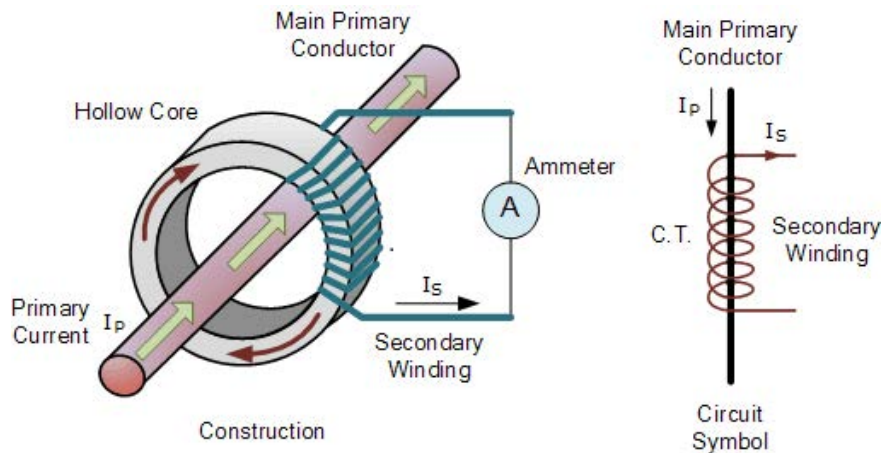


Figure 3.1.13: Current Transformer

Generally current transformers and ammeters are used together as a matched pair in which the design of the current transformer is such as to provide a maximum secondary current corresponding to a full-scale deflection on the ammeter. [33] In most current transformers an approximate inverse turn's ratio exists between the two currents in the primary and secondary windings. This is why calibration of the CT is generally for a specific type of ammeter.

3.1.14 USB Wi-Fi Dongle

In our project our main medium of communication is wireless. So, we have picked up this USB Wi-Fi Dongle which we have connected to our USB port of Raspberry Pi. The basic function of this particular device is very simple. Only used for transmission of data.



Figure 3.1.14: USB Wi-Fi Dongle

The Wi-Fi Dongle we have used for our Project has a radio frequency of 802.11n and a transfer speed up to 150Mbps. Wireless USB Adapter is a simple and secure way to connect your Windows[®]-based notebook or desktop computer to Wireless-G or Wireless-N network for surfing the Internet, email, online chat and Facebook. Easy setup with the Adapter gets you up and running fast, while compatibility with Wireless-G networks allows hassle-free connection flexibility.

3.1.15 Distribution Board

A distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. In our plexus oriented electricity bill surveillance system from variac the total load goes to the distribution board then the load distributes to the step down transformer and the testing loads. So basically our distribution board has 1 input and 2 outputs. [34]



Figure 3.1.15: Distribution Board

3.2 Software Specifications:

3.2.1 Tools:

1) **PHP**- php is a very common and very much used general-purpose scripting language that is mainly used in web development process and is indeed very easy to use especially for us students who are interested in web development. Php stands for Personal Home page where the meaning itself says it all about the definition, but now it is mainly referred to as recursive backronym. The codes that are written in PHP can be embedded into HTML code, or it can be simply used as various types of web template systems. The php codes maybe executed with a command-line interface (CLI).



Figure 3.2.1: logo of PHP

2) **Laravel** [for website backend and frontend]: Laravel is a web application framework with expressive, elegant syntax. We believe development must be an enjoyable, creative experience to be truly fulfilling. Laravel attempts to take the pain out of development by easing common tasks used in the majority of web projects, such as authentication, routing, sessions, queuing and caching.



Figure 3.2.2: Logo of laravel

3) GitHub- It is also a web-based Git repository hosting service. It manages all the source code management that has been done in laravel and it has the functionality of adding new features to our system which is absolutely necessary. Not only that, it has been used for the version update of our system. However, it has the collaboration features such as bug tracking, feature requests, task management for every project.



Figure 3.2.3: logo of Github

4) Android Studio- As our system also supports android technology we used android studio. Android studio is an official integrated development environment (IDE) for android platform development. Moreover, it is available for download in Windows, OS X and Linux.



Figure 3.2.4: Logo of android studio

5) JavaScript- JavaScript is ought to be the most high-level, dynamic type of interpreted programming language. Alongside of PHP, HTML and CSS, it is one of the essential technologies of all times. Most of the websites use it and it is very much essential to the web developer's world. It is prototype-based with first-class functions, making it a multi-paradigm language supporting OOP.



Figure 3.2.5: logo of JS.

6) MySQL [for storing all the data]:

MySQL is an open source relational database management system (RDBMS) based on Structured Query Language (SQL).



Figure 3.2.6: MySql

7) Ionic Framework [for mobile app]:

Advanced HTML5 Hybrid Mobile App Framework. It is a complete open-source SDK for hybrid mobile application development. Provide tools like CSS, HTML5 and Sass. Certain apps can be processed and distributed through app stores and is a really easy process



Figure 3.2.7: Ionic Framework

3.2.2 Interfacing from Hardware to Software:

As a hardware part we used raspberry pi and adruino to be our main core components which did almost all the communication part. It was indeed a difficult task for us to find out how to make communication within them. Then after collecting information's and going through all the surveys and papers we find out the ultimate goal. For communication part, raspberry pi is the main communication which has been attached with a Wi-Fi module which transmits the data. No matter in which world you are at the raspberry pi network will make sure that you can access the network at any possible time.

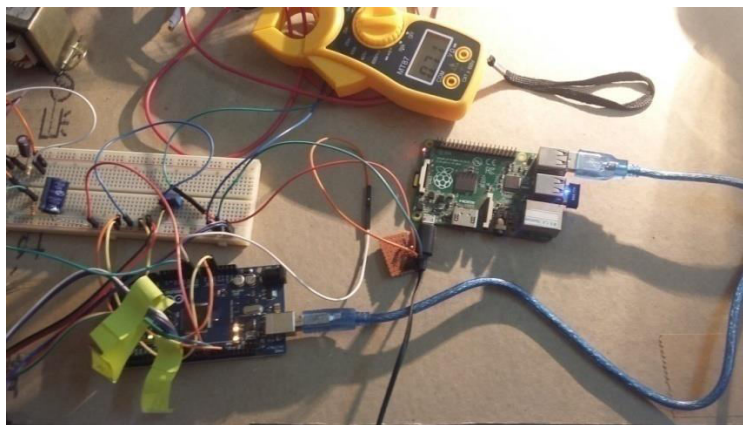


Figure 3.2.2.1: interface between hardware and software

3.3 Safe Sequence & Calibration

In our Plexus Oriented Electricity Bill Surveillance System we have used all the safety procedures that we could to ensure the optimum safety and security to the consumers and well as we had to focus on our precision of work. Craftsmanship was an important factor that did play a part. We have implemented a few techniques to achieve these goals.

3.3.1 Tamper Detection

One of the optional features is tamper-proof energy metering. If this option is enabled (factory set), the energy meter will function normally even when tampered by one of the three basic tampering methods, including earth tampering. The tampering event is stored in the internal non-volatile memory and the indication can be reset only with an external terminal after verification of password. Figure 3.3.1 shows the internal connection of the meter. ADI energy metering ASICs incorporate novel fault detection schemes that warn of fault conditions and allow the chips to continue accurate billing during a fault event. The principle of the single phase circuits is monitoring both the phase and the neutral currents. A fault is indicated when these currents differ by more than 12.5% and metering is continued using the larger of the two currents.

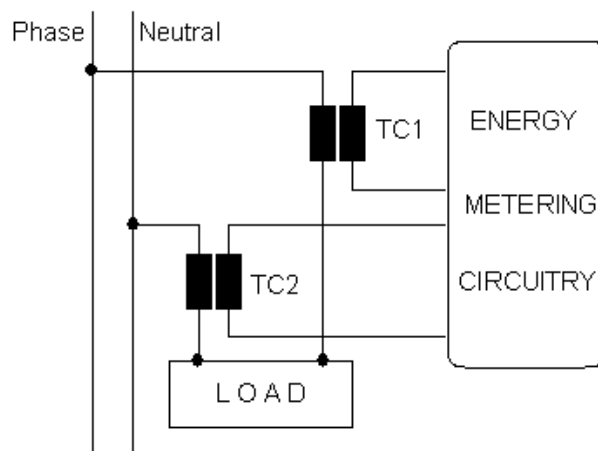


Figure 3.3.1: Internal Connection for Tampering Detection

3.3.2 RMS Calculation

Root mean square (RMS) is a fundamental of the magnitude of an ac signal. Its definition can be both practical and mathematical. Defined practically, the RMS value assigned to an ac signal is the amount of dc required to produce an equivalent amount of heat in the same load. Defined mathematically, the RMS value of a sampled signal $V(t)$ is:

$$V_{rms} = \sqrt{\frac{1}{N} \sum_{i=1}^N V^2(i)}$$

Figure 3.3.2 shows the algorithm implemented for the RMS calculation using samples of the input waveform by means of the signal path in the energy metering chips (Moulin E - RMS Calculation for Energy Meter Applications). The absolute value of the two's complement input is taken first to reduce the number of bits involved. Because the signal is squared afterwards, this block does not affect the final results.

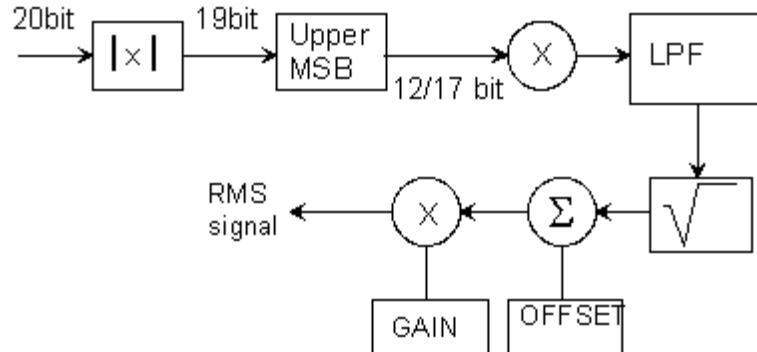


Figure 3.3.2: RMS Calculation Signal Path

The upper 12 bit of the voltage channel and 17 bit of the current channel are then extracted to be used in the RMS algorithm. The signal is then squared and low-pass filtered to extract the dc component. After the low-pass filter is settled down, the square root is taken and an offset compensation applied. Gain compensation and conversion to true RMS information is then applied to enable the display of the actual value on an LCD display.

3.3.3 RMS Calculation Error Compensation

The expected outcome of an RMS calculation is unbiased and stable information. Because signals and signal processing are not ideal, the calculation may be affected by the offset in the input signal and the ripple effect of the multiplication. A sine wave signal with a small offset:

$$V(t) = V_{os} + V \cos(\omega t)$$

After the square operation yields to:

$$V^2(t) = V_{os}^2 + \frac{V^2}{2} + 2 V_{os} V \cos \omega t + \frac{V^2}{2} \cos 2\omega t$$

If the averaging is too short, ripples with ω and 2ω frequencies affect the RMS calculation. A low-pass filter after the square function eliminates this ripple frequency noise. The cutoff frequency of the filter should be low enough to attenuate the ripple frequency by at least 40 dB (Figure 3.3.3). For errors lower than 0.1%, more than 3540 samples are needed, taken over 2.03 seconds at the given sampling frequency. The corresponding error affecting the RMS calculated values is given by:

$$Error(\%) = \frac{100}{(1 + 2^{-9})^n}$$

The 'n' here represents number of samples.

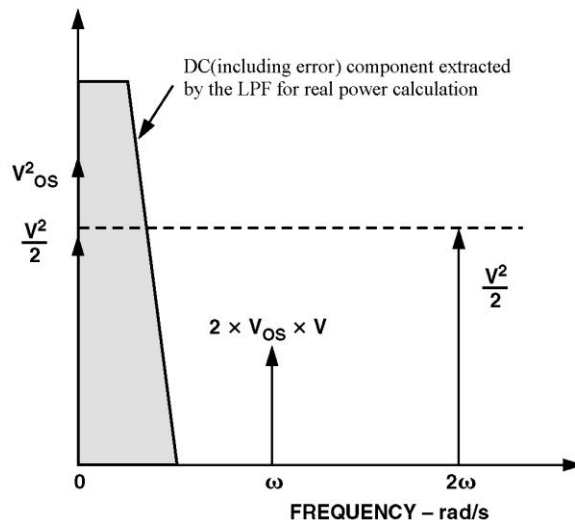


Figure 3.3.3: Effect of input offset on RMS calculation

3.3.4 Real time Data Calibration

The techniques that we have used to achieve our goals are having quite remarkable. After calibration we have tested our system and the calibration done is 99.99% accurate. The below image shows that there are no leaky flows of current in our system and it's calibrated to near perfect. We have used our Clamp meter and 16x2 LCD display data's to compare over current flow (amps).



Figure 3.3.4: Calibration Accuracy of the System

Chapter 4

PROPOSED WORK

In this chapter we have discussed about our proposed work that been done. The workflow diagram shows how our work flow goes on. We will see our Schema and ER diagram of our software solution to our thesis project. Moreover we will see our USE case diagram and some necessary Pseudo Codes.

4.1 Proposed Work:

In this paper we are going to mention about a complete system of an electric meter which includes hardware and software support. Hence with the help of it we designed a system that can generate bills of a user very easily. And time to time the billing status keeps on getting updated which was a very challenging task for us. However in order to make it possible we divided our work into hardware and software part. At first we designed a complete hardware system which included a full design of a meter where we used a lot of electronic components which is mentioned in the paper. Calibration was a bit of challenging in the hardware part and then we started with the software part where we interfaced the hardware with the software using raspberry pi and programmed it. We also made a web interface followed by a mobile application for both IOS and android application.

In the upcoming few sections we will see the pseudo codes of the basic algorithms that we need to formulate the proposed system. After that, the result analysis section is where we will show the results.

4.2 Workflow:

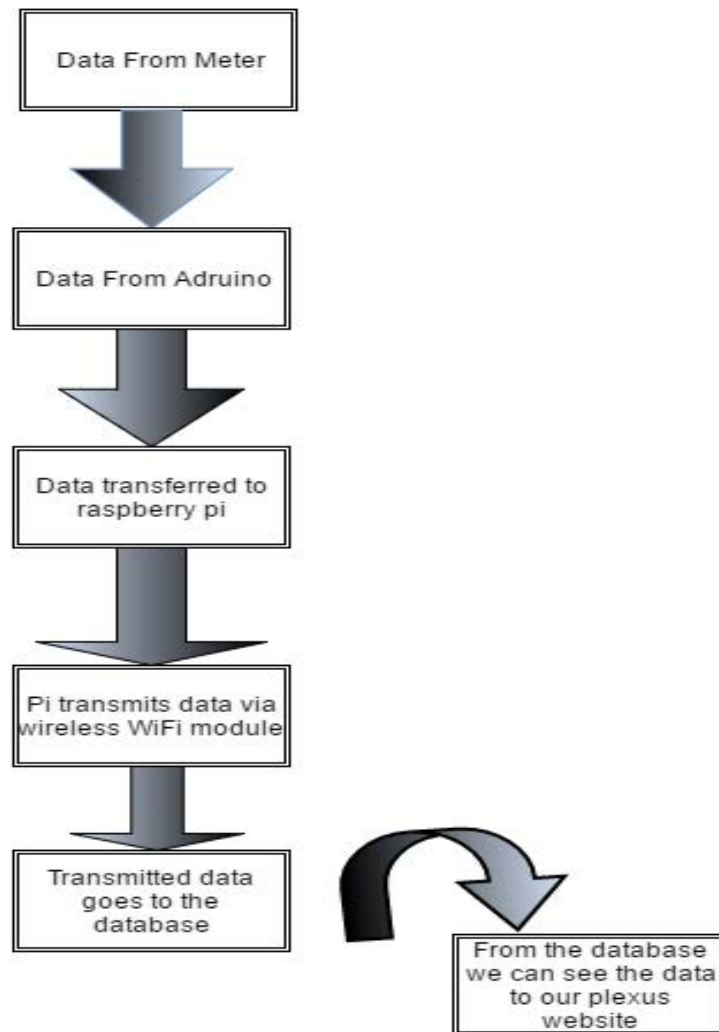


Figure 4.1: Workflow diagram of our process

Our first work is take the data from the meter that we created from where we transmit the data to arduino mega which is then transferred to the raspberry pi which allows to transmit the wireless data via wireless Wi-Fi module and the data that has been transmitted goes to the expected database which stored the data and hence lastly we can access plexus website and view our final result that has been generated.

4.3 Use case:

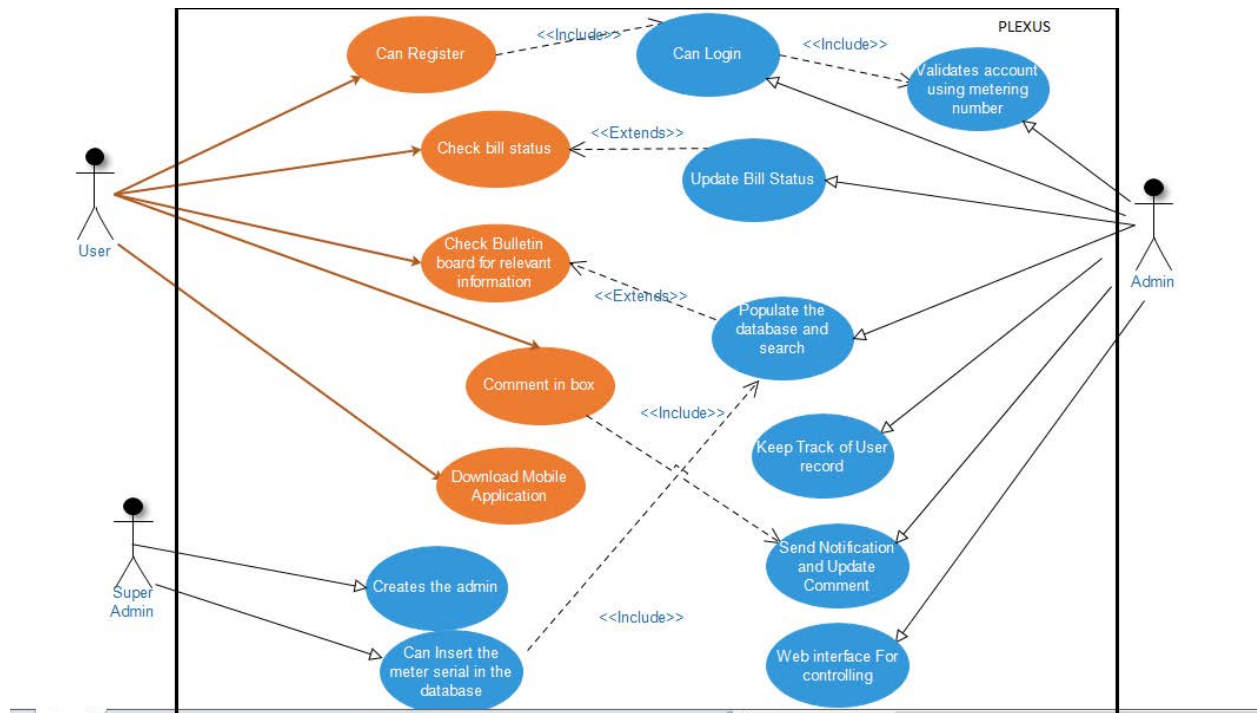


Figure 4.2: Use case diagram of our system

Use Case Name: Plexus Oriented Electricity Bill Surveillance System

Primary Actor: User/Customer

Stakeholders and Interests:

- User/Customer: Wants easy access to our website. Wants to make easy viewing of the bill status.
- Admin: Populate database and oversee the system.
- Super Admin: It creates the admin and inserts the meter serial in the database.

Brief Description: This use case describes how a user/customer can search for home bill status and the calculated amount of bill. Also, how they can comment, and see bulletin board for important notifications.

Relationships:

- Associations: User
- Extend: Populate database and Search, Update bill status
- Include: Login Verification, Send notification and Update Comment
- Generalization: -

Pre-Conditions: The User has been authenticated by making sure that he/she put the meter's id correctly.

Post-Conditions:

- The patients are able to check bill status, comment in box and also download mobile application.
- The system will remember if the user logs in.

Normal Flow of events:

- The patient can register.
- The patient can check for bill status with calculated amount.
- The patient will have a necessary bulletin board for relevant information made by the admin
- The admin populates the database.
- The super admin who is the one responsible to create an admin.
- The admin updates bill status and keep track of user record where it sends notification and update the comments of the user.

If the user wants to make a new comment

The S-1: send notification and update comment is performed.

If the patient wants to check bill status

The S-2: update bill status and show the bill

Sub flows:

S-1: New comment

1. The admin asks the user for possible queries and questions.
2. The admin will try to answer their questions regarding any queries

S-2: Bill Status

1. The admin asks the user to check bill status.
2. The admin in turn updates the bill status.

External/Alternate flow:

- For a bill status to be complete the admin has to see if the user paid the bill or not
- If bills due and not paid the admin can update the comments for the user giving him/her a warning.

Special Case:

- It updates the bill every second and is hence a live process throughout.
- Our system can take at most 26 flats.
- The admin will give full support.
- The user cannot register until and unless he/she inputs the meter id they have given.

4.4 SCHEMA DIAGRAM:

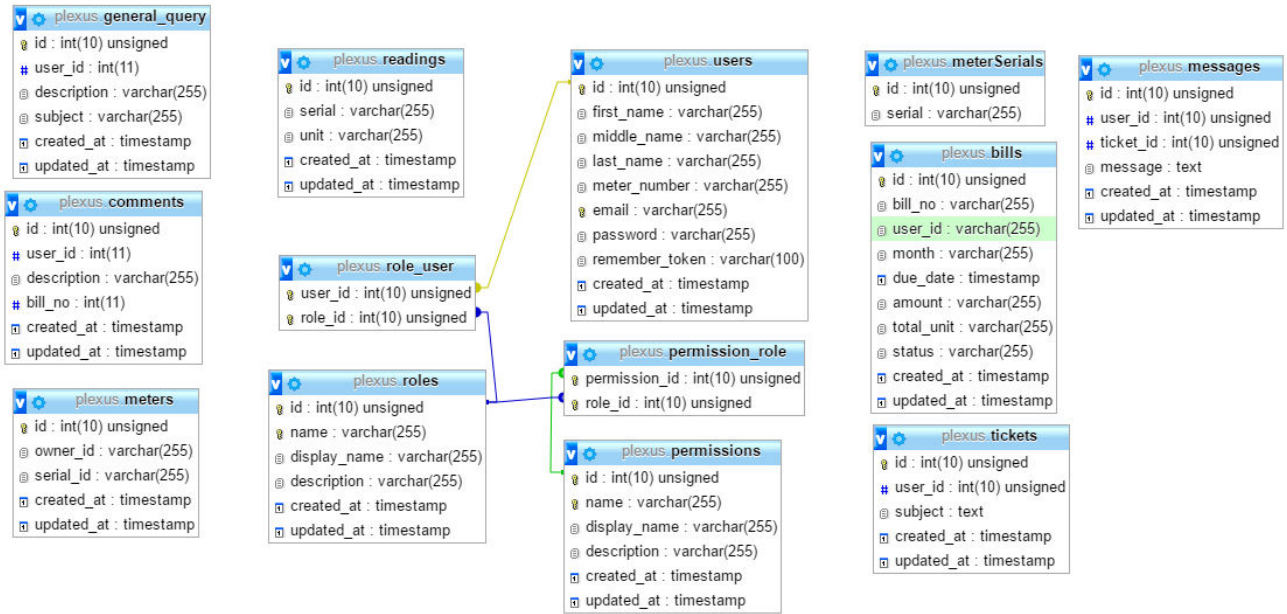


Figure 4.3: Schema Diagram of the system

This graphic describe the tables in the Plexus Schema

The *general_query* have the following attributes:

- Columns: id, user_id, description, subject, created_at and updated_at.

The *comments* have the following attributes:

- Columns: id, user_id, description, bill_no (int), created_at, updated_at.

The *meters* have the following attributes:

- Columns: id, owner_id, serial_id, created_at, updated_at.

The *readings* have the following attributes:

- Columns: id, serial, unit, created_at, updated_at.

The *role_user* have the following attributes:

- Columns: `user_id`, `role_id`.
- Relationship:
 - Column `user_id` relates one or more rows of the table `role_user` to one row of the table `users` with the corresponding value of `user_id`.
 - Column `role_id` relates one or more rows of the table `role_user` to one row of the table `permission_role` with the corresponding value of `role_id`.

The *roles* have the following attributes:

- Columns: `id`, `name`, `display_name`, `description`, `created_at`, `updated_at`.

The *users* have the following attributes:

- Columns: `id`, `first_name`, `middle_name`, `last_name`, `meter_number`, `email`, `password`, `remember_token`, `created_at`, `updated_at`.

The *permission_role* have the following attributes:

- Columns: `permission_id`, `role_id`.
 - Column `permission_id` relates one or more rows of the table `permission_role` to one row of the table `permissions` with the corresponding value of `id`.
 - Column `role_id` relates one or more rows of the table `permissions_role` to one row of the table `roles` with the corresponding value of `id`.

The *meterSerials* have the following attributes:

- Columns: id, serial.

The *bills* have the following attributes:

- Columns: id, bill_no, user_id, month, due_date, amount, total_unit,status,created_at, upated_at.

The *tickets* have the following attributes:

- Columns: id, user_id, subject, created_at, updated_at.

The *messages* have the following attributes:

- Columns: id, user_id, ticket_id, message, created_at, updated_at.

4.5 ER DIAGRAM:

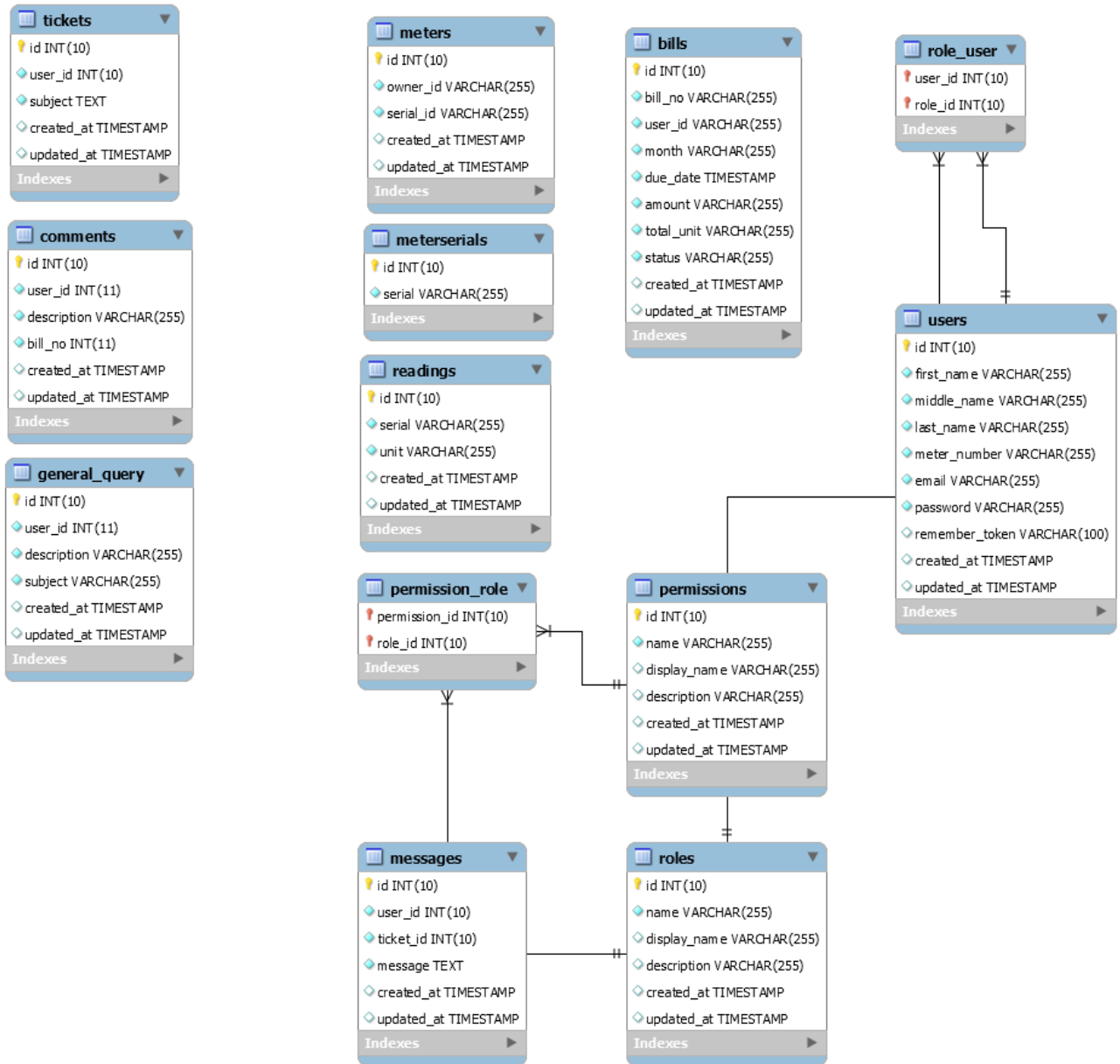


Figure 4.4: ER DIAGRAM

This is the ER diagram our database showing up all the relationships, primary actors, foreign actors and others to justify the validation.

4.6 PSEUDO CODES:

Pseudo code is an informal high-level description of the operating principle of a computer program or other algorithm.

It uses the structural conventions of a programming language, but is intended for human reading rather than machine reading. Pseudo code typically omits details that are essential for machine understanding of the algorithm, such as variable declarations, system-specific code and some subroutines. The programming language is augmented with natural language description details, where convenient, or with compact mathematical notation.

4.6.1

Pseudo Code

Liquid Crystal Display

Input: Data from MCU

Output: Display

1. Set Data pins of Vdd and ground
2. Set Data pins of memory storage
3. Adjust backlit power
4. Print volt= V
5. Print current= A
6. Print watt/hour= W/h
7. Print unit= u
8. end

Table 4.1: Pseudo code for Liquid Crystal Display

The main purpose of this pseudo code is for displaying the output through our 16x2 LCD display which allows us to view the necessary information that we need for the calculation process.

4.6.2

Pseudo Code

Find Watt per hour

Input: Current and volt

Output: Watt per hour

1. Read voltage from sensor 1
2. Read current from sensor 2
3. Calculate watt
4. $\text{Watt} = \text{current} * \text{volt}$
5. $\text{Watt/hour} = (\text{current} * \text{volt}) / 3600$
6. Return watt/hour to LiquidCrystal
7. end

Table 4.2: Pseudo Code for Watt/Hour

This includes the main idea of how to find the wattage from any electrical appliances we use.

Basically the watt/hour is required to calculate the unit.

4.6.3

Pseudo Code

Get Unit

Input: Energy and Watt

Output: Unit

- | |
|--|
| <ol style="list-style-type: none">1. Read watt2. Find Energy3. Energy=Energy + watt4. Return Energy5. Find Unit6. Unit=Energy/10007. Return Unit to LiquidCrystal8. End |
|--|

Table 4.3: Pseudo code of get unit

The pseudo code represents the output for the unit which is the main calculation of our process. Without it the electric bill calculation is quite tough.

This is the main pseudo codes we implemented on our hardware using arduino mega as MCU. It includes code for: **LiquidCrystalDisplay, Wattage/hour and Unit.**

Chapter 5

System Architecture

In this particular chapter we will see the whole Architecture of our system. On what principle or ground we did build our system. We will also go on to some of the real test pictures that will further justify the whole solution.

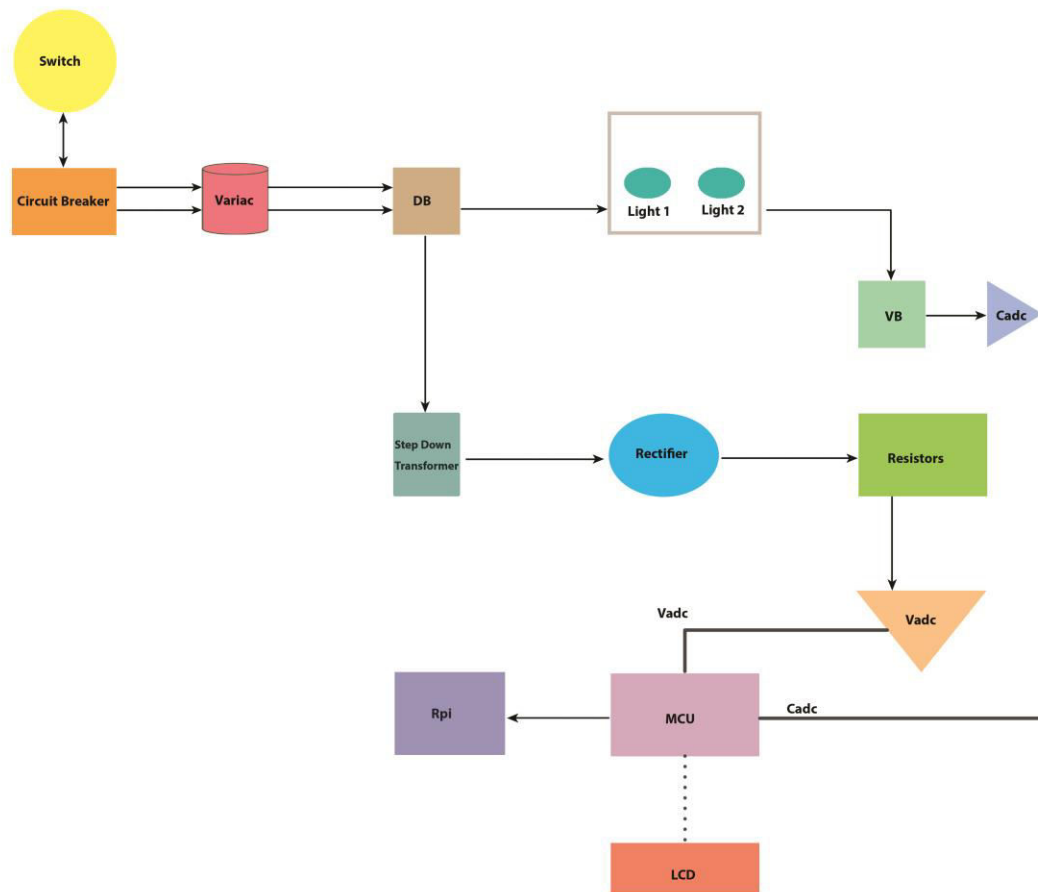


Figure 5.1: System Block of the system

The system architecture is quite simple but effective as we can see that the main line comes through the switches via a circuit breaker and the lines go to the input variac. As we know the AC current we get to use in our home is not always stable, so that is why we have used variac. The output of the variac goes to the Distribution board and from distribution board we get the required supply of electricity. The lights are electrically connected via distribution board. The lines of these lights are passed through the current transformer or know as CT and also know as Hall Effect Sensor. The output of the hall effect sensor directly goes to the input of our microcontroller unit. In this case we have used our MCU as ADRUINO MEGA. Another component line that comes out from the distribution board is the step down transformer. We have used 12-12 v step down transformer. The output of the transformer directly goes to one end of the rectifier where it is connected with registers and POT and from there we get another analog input of the MCU. The MCU is also connected with 16x2 LCD display, where we can see the ampere and volts along with the watt per hour usage and unit. The calculation of the electric unit is done as follows:

The formula for calculation the number of volts is:

$N = (P \cdot t)$, where P is power of appliance in KW and t is the time of usage in hours. For example, if you use a 1000 watt appliance for 1hour, 1 unit electricity is consumed.

We calculate Wattage from the product of voltage and the current for appliance. Voltage is measured in volts and current in amperes (or amps)

(W) Wattage = volt (V) x current (A)

KWh= Wattage (W)/1000

Below are some of our real design illustrations:

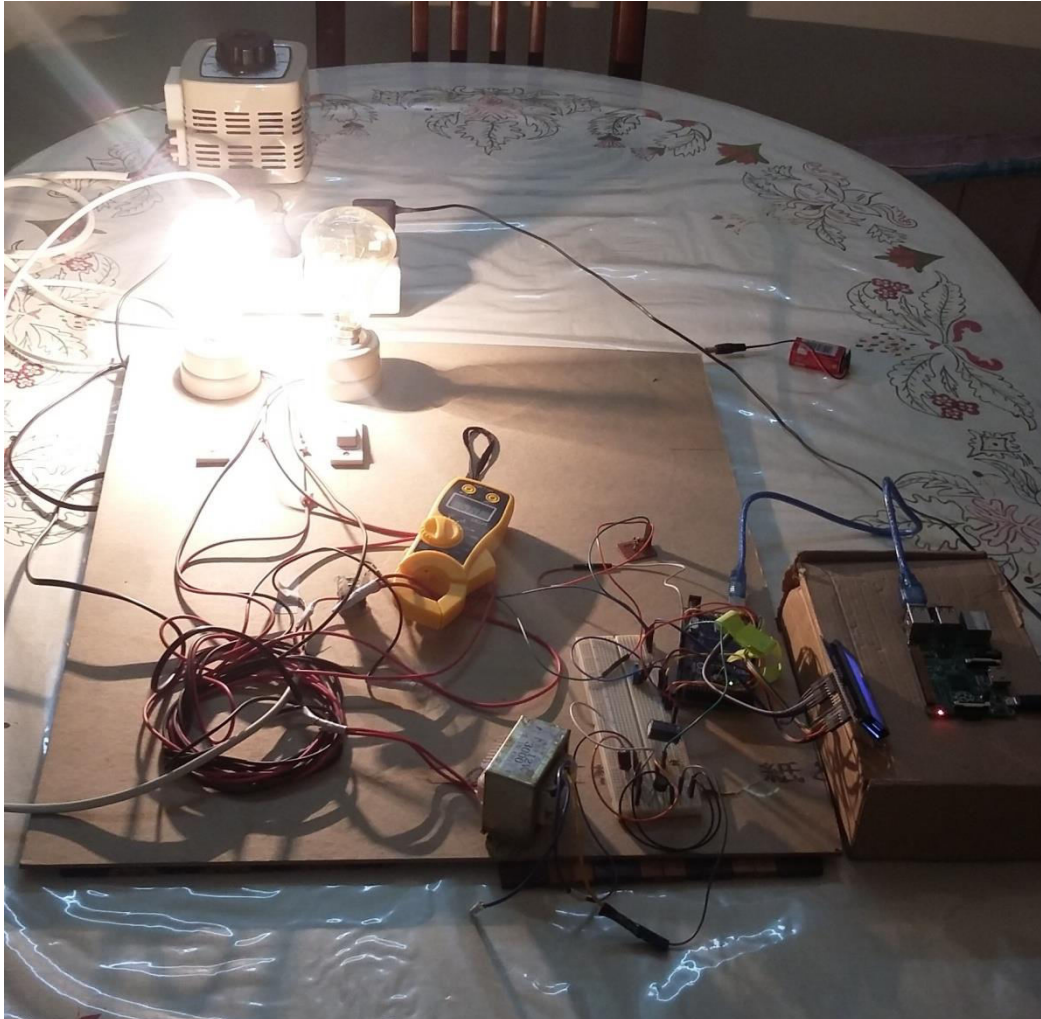


Figure 5.2: Live System

Figure 5.2 shows all the possible hardware components used to make the thesis project a success. We can see the whole system is 'LIVE' and it's transmitting data to our specified database. In the figure 5.2 we can see that there are two bulbs where one of them is switched on. One interesting thing about our architecture is that without even having electricity supply all the time our system will run pretty smoothly as it has a dual power mode capability. It can directly start consuming the current flowing through the adapter or power that is supplied by a rechargeable 9V battery.

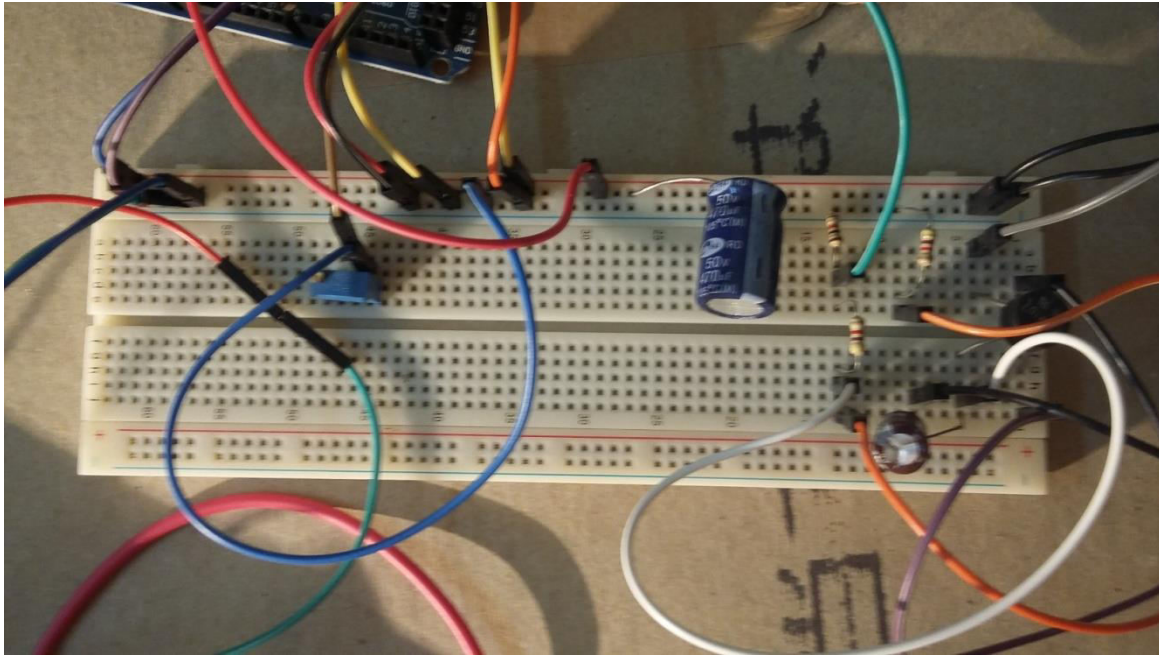


Figure 5.3: Breadboard Connections

Here in the figure 5.3 we can see that there are a lot of wires that are connected to the breadboard. Some notable components that are visible are Rectifier Diode, Capacitors, POT, resistors etc. The 10K POT used here has a purpose. It maintains the contrast ratio of our 16x2 LCD display.

Chapter 6

Result and Analysis

In this particular chapter we will start with the cost estimation of our thesis project including both of our hardware and software analysis and calibration. The chapter also includes analysis of the Mobile solution.

6.1 Cost Estimation

One of the biggest challenge we faced as an engineer student is that to reduce the cost margin and at the same time keeping in mind that not to compromise with safety and precision of data output. We have identified our unique cost in two situations:

- i) Best Case Scenario
- ii) Worst Case Scenario

Let's know some facts first. As we are using raspberry pi and we know that pi has 26 GPIO (General Purpose Input Output) pins. So, a maximum number of 26 connections can be made through one raspberry pi. One MCP 3008 has 8 channels at 10 bits. It means that per MCP 3008 can take maximum o 8 different inputs. But we have 2 input signals coming to our MCU. So, a maximum of 4 connections can de bone. The same goes on for Raspberry Pi also. We will need 2 pins to find the difference between volt and ampere to get wattage per hour. So, a maximum of 13 consumers can use a single Raspberry Pi. But if we can multiplex these we can connect more than 100 consumers. But for ideal case we use two GIPO pins per consumer.

Unit	Device	Cost
1	Raspberry Pi	4500 BDT
1	MCP 3008	226 BDT
Per installation	Cables and installation	50 BDT

Table 6.1: Cost of Devices

Now let's see costing of two scenarios from where we can profit response will come.

i) Best Case Scenario

If there are multiple consumers in same building. As we can see that for the apartments we have in Bangladesh. So, a maximum of 13 consumers can get this wonderful service per package.

$$\begin{aligned}\text{Cost per consumer} &= (1 \times \text{RPi}) + (3.25 \times \text{MCP3008}) + (13 \times 50) / 13 \\ &= (4500 + 731.5 + 650) / 13 \\ &= 5,884.5 / 13 \\ &= 453 \text{BDT/person (Appx).}\end{aligned}$$

The good news is that it is only a one form installation. So, the user need to pay only once in their whole life.

ii) Worst Case Scenario

If there exists a single consumer in a building, like people living in single house (not apartments).

$$\begin{aligned}\text{Cost per consumer} &= (1 \times \text{RPi}) + (1 \times \text{MCP3008}) + (1 \times 50) / 1 \\ &= (4500 + 226 + 50) / 1 \\ &= 4,776 \text{BDT/person (Appx).}\end{aligned}$$

The only positive thing is this is a onetime payment.

6.2 WEB Analysis

i) User's View

We have our very own website which has been up and live since January 2016. As we were running continuous and vigorous tests on our web site to ensure it's ultra reliability in transmitting data without any delay. While designing the website we kept quite a few things on our mind. They are:

- i. Minimum Delay
- ii. Maximum CPU utilization
- iii. Maximum Throughput
- iv. Minimum response time
- v. Concurrent data handling

The link of our website is www.plexus.tech

Now, let's take a look around the website and follow some of it's interesting features.

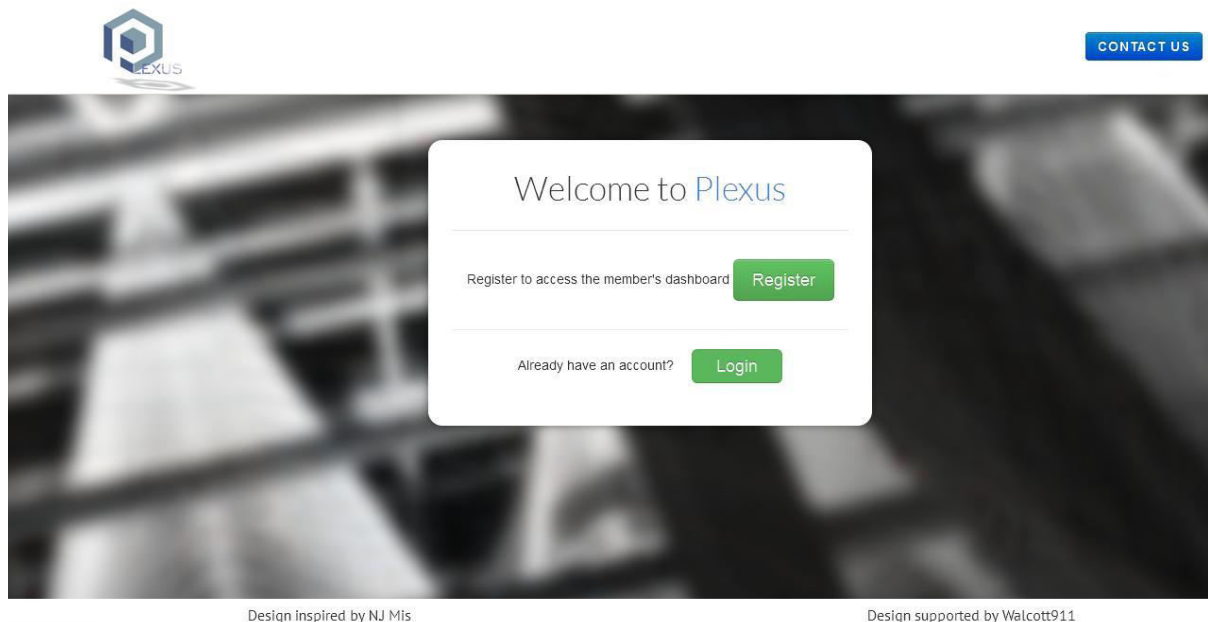
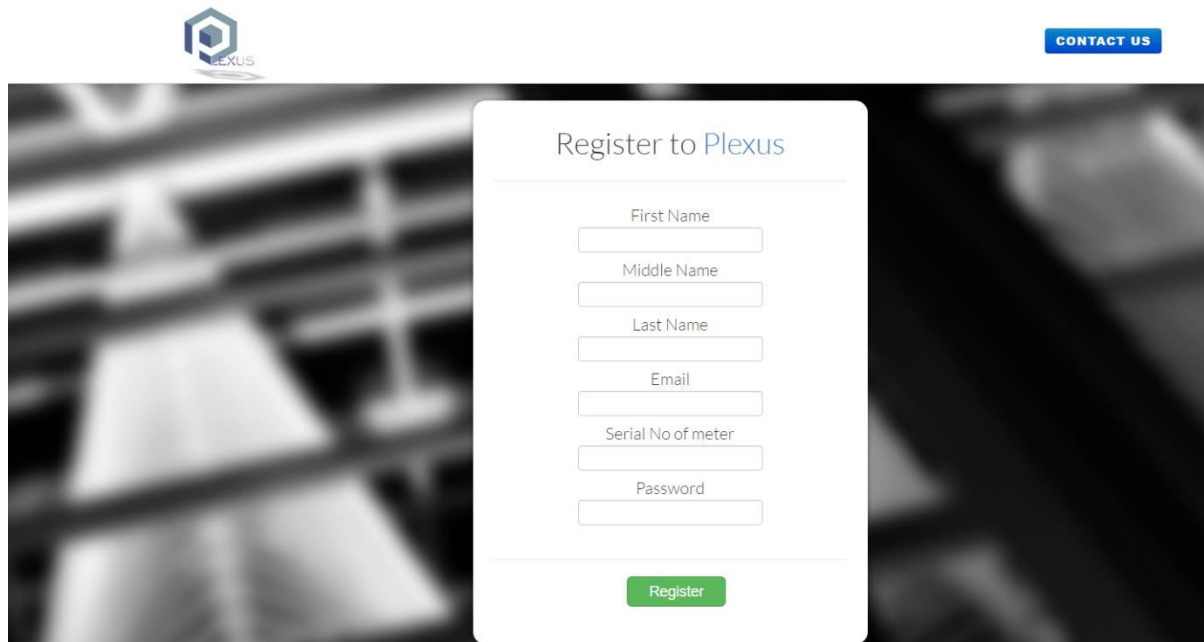


Figure 6.2.1 Home Page

As we can see in the figure (6.2.1) that when we are in the homepage of our website the users can “Register” with their specific meter id which has to be in the database that is given by the super admin. After that the user will be able to “Login” and hence can see their bills and other specific data.



The image shows a web registration form titled "Register to Plexus". The form is centered on a dark background with a blurred architectural pattern. In the top left corner, there is a logo for "PLEXUS" consisting of a blue hexagon with a white geometric shape inside. In the top right corner, there is a blue button with the text "CONTACT US". The registration form itself is a white rounded rectangle containing the following fields from top to bottom: "First Name", "Middle Name", "Last Name", "Email", "Serial No of meter", and "Password". Each field is represented by a white rectangular input box. At the bottom of the form is a green button with the text "Register".

Figure 6.2.2: Register Page

The user has to insert all of these mandatory data to register to our website.

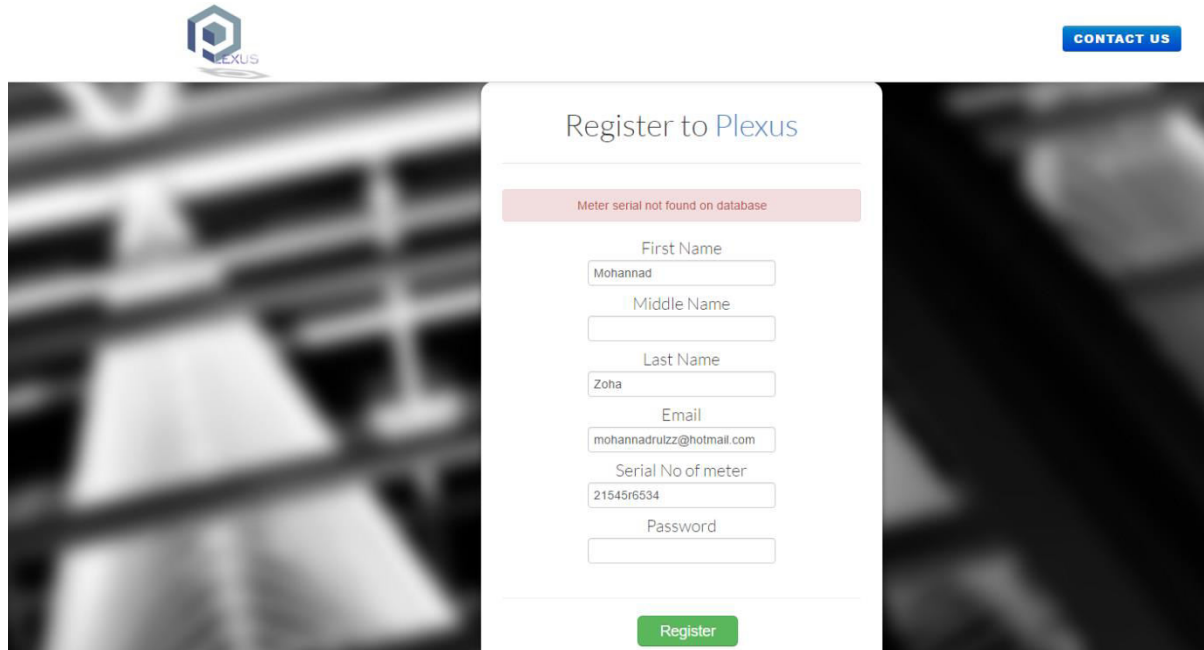


Figure 6.2.3: Registration Failure

If any fraud person wants to register and try to hack our data he/she will be unable to do it because they would not have the specific serial No of meter. As well as once a meter is registered to a person it cannot be registered using the same serial meter ID by someone else, so it is a pretty safe process. Furthermore, we have also used 256 bit AES and two-step verification process for the security purpose of our system so it is more or less impossible for the hacker's or manipulative people to access the site and gain control over it. Even, it will take a million years for a quantum computer to break through 256 bit AES secured system.

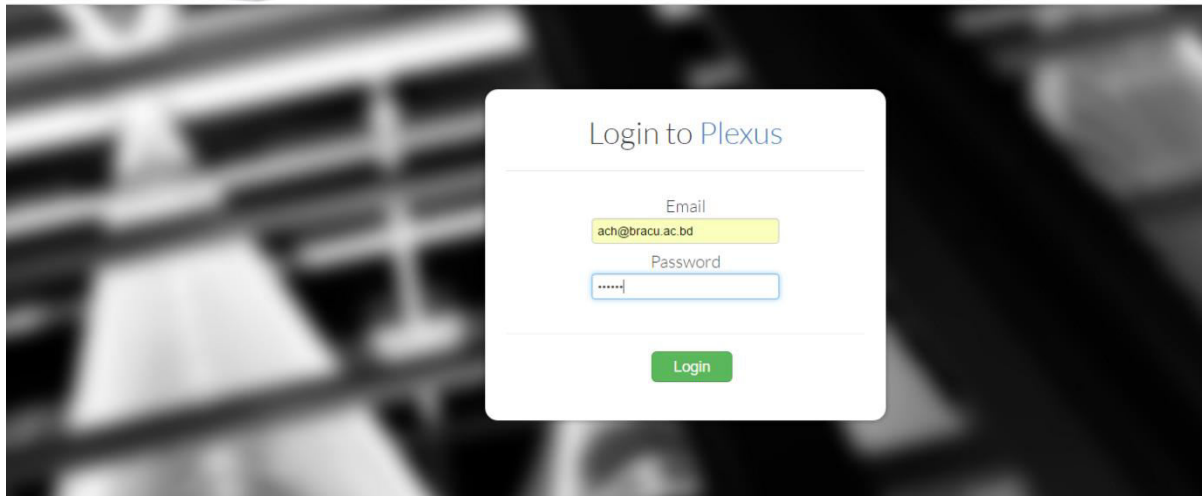
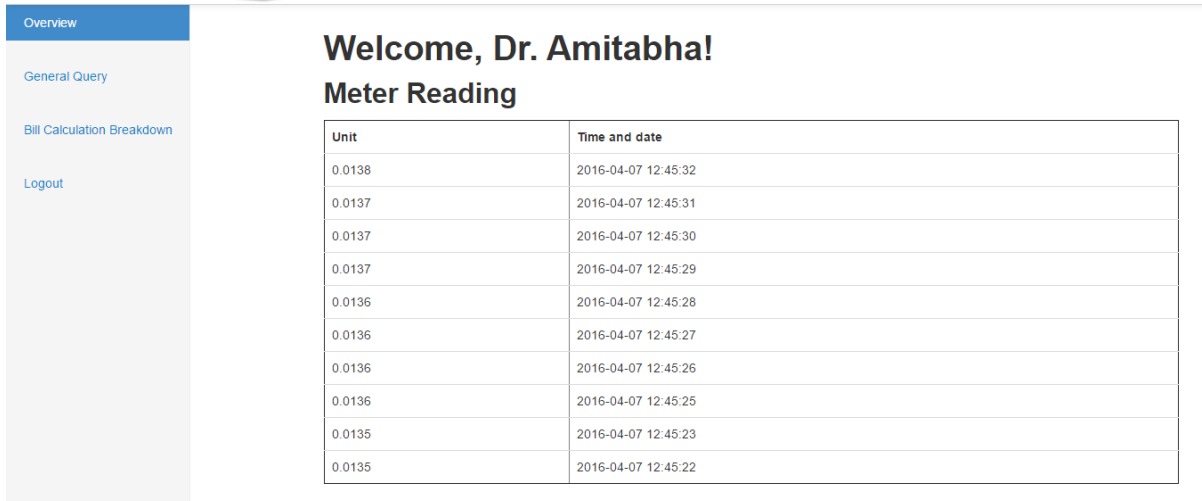


Figure 6.2.4: Login page

As we have registered through Dr. Amitabha's email id so he is the specific user of the system along with his meter that is already connected through our website which is done by the super admin.



Unit	Time and date
0.0138	2016-04-07 12:45:32
0.0137	2016-04-07 12:45:31
0.0137	2016-04-07 12:45:30
0.0137	2016-04-07 12:45:29
0.0136	2016-04-07 12:45:28
0.0136	2016-04-07 12:45:27
0.0136	2016-04-07 12:45:26
0.0136	2016-04-07 12:45:25
0.0135	2016-04-07 12:45:23
0.0135	2016-04-07 12:45:22

Figure 6.2.5: User Dashboard

According to the Figure 6.2.5 we can see that our system greets Dr. Amitabha with a welcome message on his dashboard. On the left hand side we see some tabs such as overview, general query, bill calculation breakdown and logout. We can also see the live data transmission of the meter reading that Dr.Amitabha has been using and is specified with exact time and date. If we look carefully the data is streamed every second and gives us very precise information about the unit.

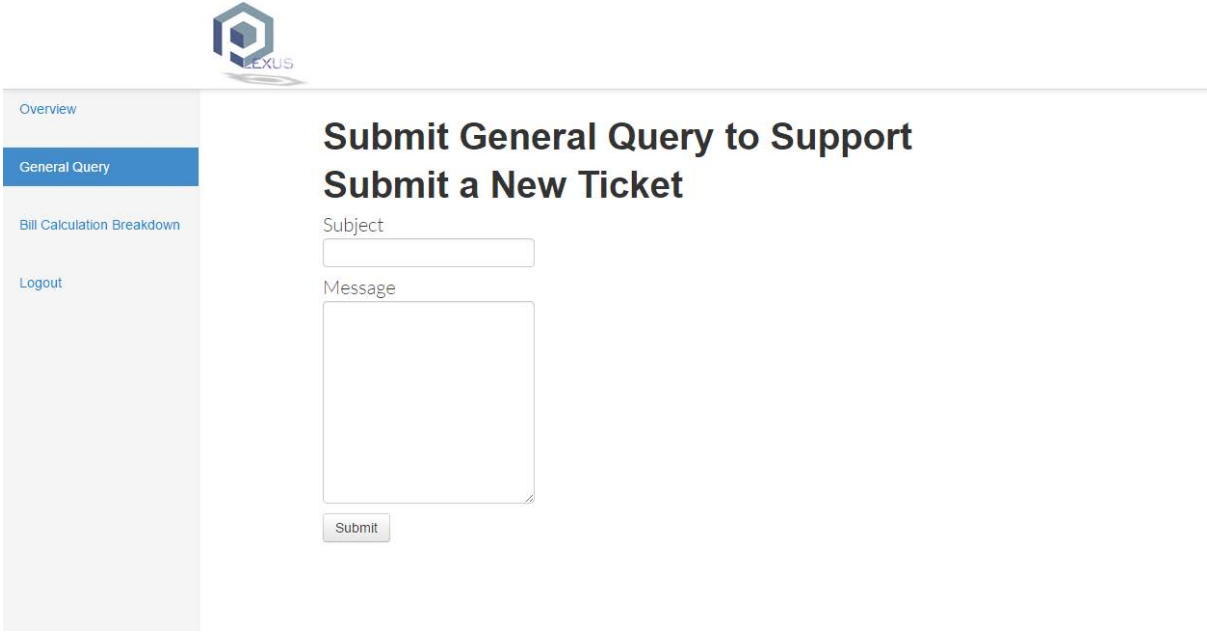


Figure 6.2.6: General Query for Users

It has a subject phase where the user can specify a subject and regarding that the user can write a message regarding any issues they want to query about and is instantly updated to the admin and the admin responses.

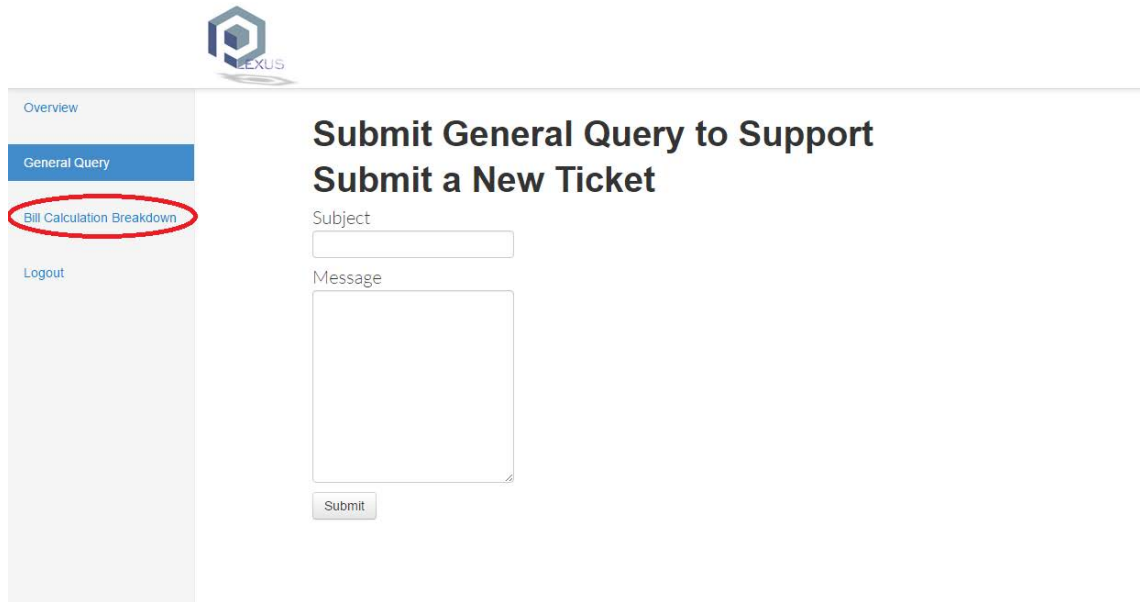


Figure 6.2.7: Bill Calculation Breakdown I

This directly leads to the DESCO homepage where the current tariff of electricity bill consumption per unit is shown precisely.

The screenshot shows the DESCO homepage. The header includes the DESCO logo and navigation links: Home, About Us, Home Consumers, Business Consumers, Customer Service, General Information, Safety Tips, and Others. Below the navigation, there is a search bar and a 'Tariff Rate' section. The 'Tariff Rate' section contains a table with the following data:

Sl	Customer Category	Per Unit Rate (Tk.)	Minimum Charge	Demand Charge	Service Charge 1ph	Service Charge 3ph
Category-A : Residential						
1	Life Line : From 1 to 50 units	3.33	100	15	10	30
	a. First Step : From 1 to 75 units	3.80				
	b. Second Step : From 76 to 200 units	5.14				
	c. Third Step : From 201 to 300 units	5.36				
	d. Fourth Step: From 301 to 400 units	5.63				
	e. Fifth Step: From 401 to 600 units	8.70				
f. Sixth Step: Above 600 units	9.98					
2	Category-B : Agricultural pumping	3.82	125	30		40
Category-C : Small Industries						
7	a. Flat Rate	7.66	-	40		70
	b. Off-Peak Time	6.90				
	c. Peak Time	9.24				
4	Category-D : Non-Residential (Light & Power)	5.22	100	20	10	30

Figure 6.2.8: Bill Calculation Breakdown II



Bill #	Month	Total Unit	Amount	Status	Comment
8	March	-0.9903	-2.9709	Unpaid	Comment
10	March	-0.9862	-2.9586	Unpaid	Comment
12	March	-0.9861	-2.9583	Unpaid	Comment
14	March	79	406.06	Unpaid	Comment
16	March	699	6976.02	Unpaid	Comment
18	March	404	122.39	Unpaid	Comment
20	March	48	9.242	Unpaid	Comment
22	March	48	169.082	Unpaid	Comment
24	March	48	194.082	Unpaid	Comment
26	March	404	2570.19	Unpaid	Comment
28	March	404	2570.19	Unpaid	Comment

Figure 6.2.9: Billing records

The data used for the billing records here are just sample data where we can see the Bill #, Month, Total Unit, Amount, Status and of every bill the user can comment.

37	April	< 30	100	Unpaid	Comment
28	March	404	2570.19	Unpaid	Comment

Figure 6.2.10: Real bill records

We can see some of the real bill records as we were testing our system for over 3 months. In this period we had the ability to capture some of the real time data's. In the first data we see the unit < 30 which means the unit did come less than 30 and we know the minimum bill will be 100 as per the guidelines of DESCO. So it is not worth seeing the accurate unit but in our live meter reading we can see the accurate unit with respect to time and date.

ii)Admin's View:

We have already noticed the great features of the user's view and now it is time to see the view of the admin panel.

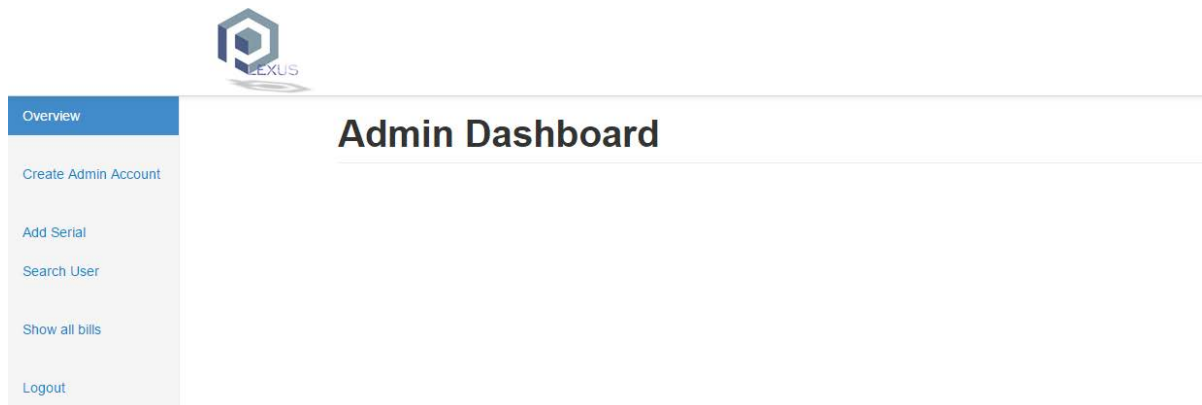


Figure 6.2.11: Admin dashboard

In the admin's dashboard we can see that there are tabs like , Create Admin Account, Add Serial, Search User, Show all bills and log out.

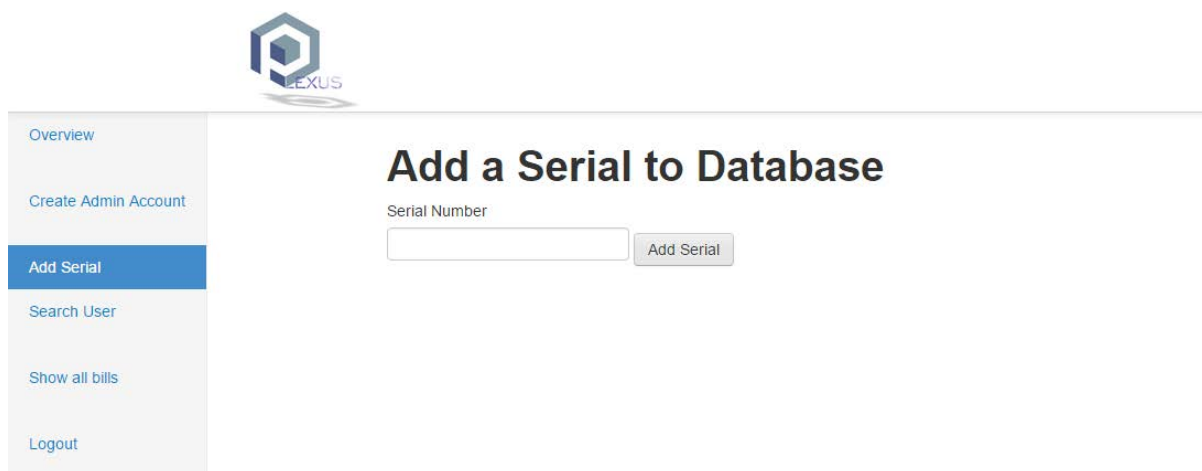
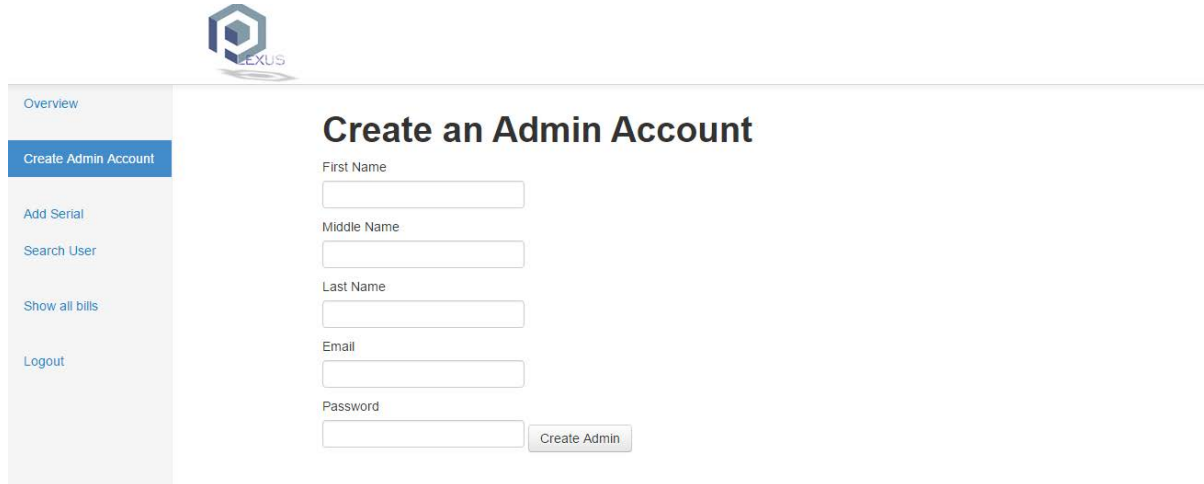


Figure 6.2.12: Admin Adding a serial to database

An admin can add a serial to the database of the specific user's meter ID. Only after that he/she can sign up/ register using this serial number.



Create an Admin Account

First Name

Middle Name

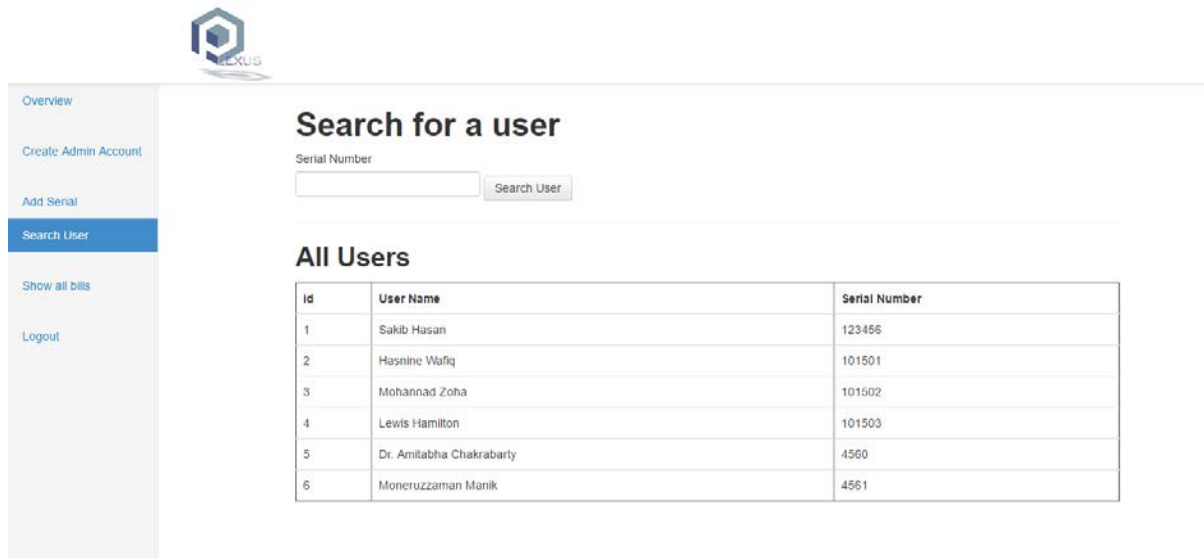
Last Name

Email

Password

Figure 6.2.13: Admin can create another Admin.

The super admin only has the power to create other admin's so that they can maintain the website which eases the pressure of the super admin monitoring all the time hence reliable.



Search for a user

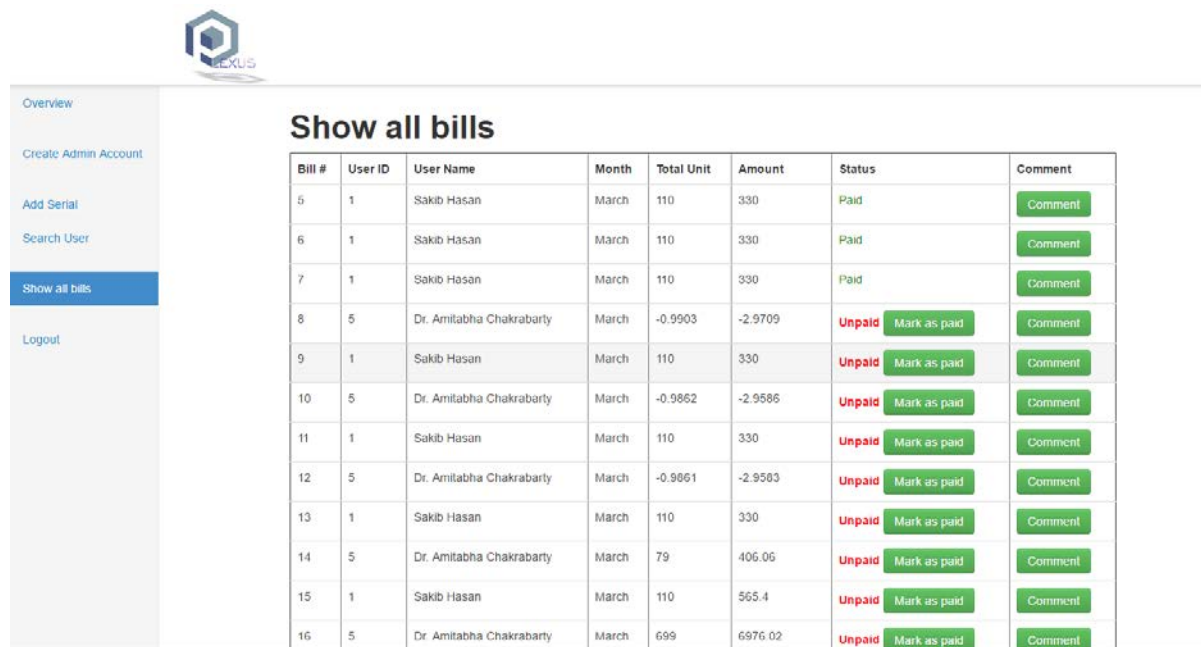
Serial Number

All Users

Id	User Name	Serial Number
1	Sakib Hasan	123456
2	Hasnine Wafiq	101501
3	Mohannad Zoha	101502
4	Lewis Hamilton	101503
5	Dr. Amitabha Chakrabarty	4560
6	Moneruzzaman Manik	4561

Figure 6.2.14: Search a user By Admin

We can visualize from the figure where the admin can search anyone in the database with the serial number and only the super admin has the power to search both admin's and the users.



Bill #	User ID	User Name	Month	Total Unit	Amount	Status	Comment
5	1	Sakib Hasan	March	110	330	Paid	Comment
6	1	Sakib Hasan	March	110	330	Paid	Comment
7	1	Sakib Hasan	March	110	330	Paid	Comment
8	5	Dr. Amitabha Chakrabarty	March	-0.9903	-2.9709	Unpaid	Mark as paid Comment
9	1	Sakib Hasan	March	110	330	Unpaid	Mark as paid Comment
10	5	Dr. Amitabha Chakrabarty	March	-0.9862	-2.9586	Unpaid	Mark as paid Comment
11	1	Sakib Hasan	March	110	330	Unpaid	Mark as paid Comment
12	5	Dr. Amitabha Chakrabarty	March	-0.9861	-2.9583	Unpaid	Mark as paid Comment
13	1	Sakib Hasan	March	110	330	Unpaid	Mark as paid Comment
14	5	Dr. Amitabha Chakrabarty	March	79	406.06	Unpaid	Mark as paid Comment
15	1	Sakib Hasan	March	110	565.4	Unpaid	Mark as paid Comment
16	5	Dr. Amitabha Chakrabarty	March	699	6976.02	Unpaid	Mark as paid Comment

Figure 6.2.15: Show all bills of the users

Here the admin can see all the bills of the users who are using the system. Moreover, the admin can update the status of the bill like paid if the bill is “paid”. If user comments on a specific bill the admin can reply to that specific bill comment using the comment button. Those whose bills are not clear the admin does not clear the status of that user, where the status is marked as “Unpaid” and once the payment is done the admin updates the status and marks it as “Paid”.



Overview

Create Admin Account

Add Serial

Search User

Show all bills

Logout

Messages

Dr. Amitabha Chakrabarty - 1 month ago

My bill is paid. Please update the info.

Hasnine Wafiq - 1 second ago

Updated. Thank you for your co-operation :)

Write Comment

Figure 6.2.16: Message and Write Comment

Over here we see that the user can comment on the specific bill for eg. Here Dr. Amitabha commented “My bill is paid, Please update the info”. Then the super admin Hasnine Wafiq comments back “Updated. Thank you for your co-operation 😊.” But if we look carefully, that the super admin only updated the status once the payment was done, not before that. So even if a user fakes that he has paid the bill then the admin is not bound to update the status.

6.3 Mobile Application Analysis

We have made an android based application for our thesis project where it will be suitable for a lot of users can access the billing records online as almost everyone have a Smartphone this days and it is easy to download and the size of the application is less than 5mb, which does not fill up the temporary memory and cache of the mobile phone. It uses multiprogramming with variable number of tasks which optimizes it's utilization.

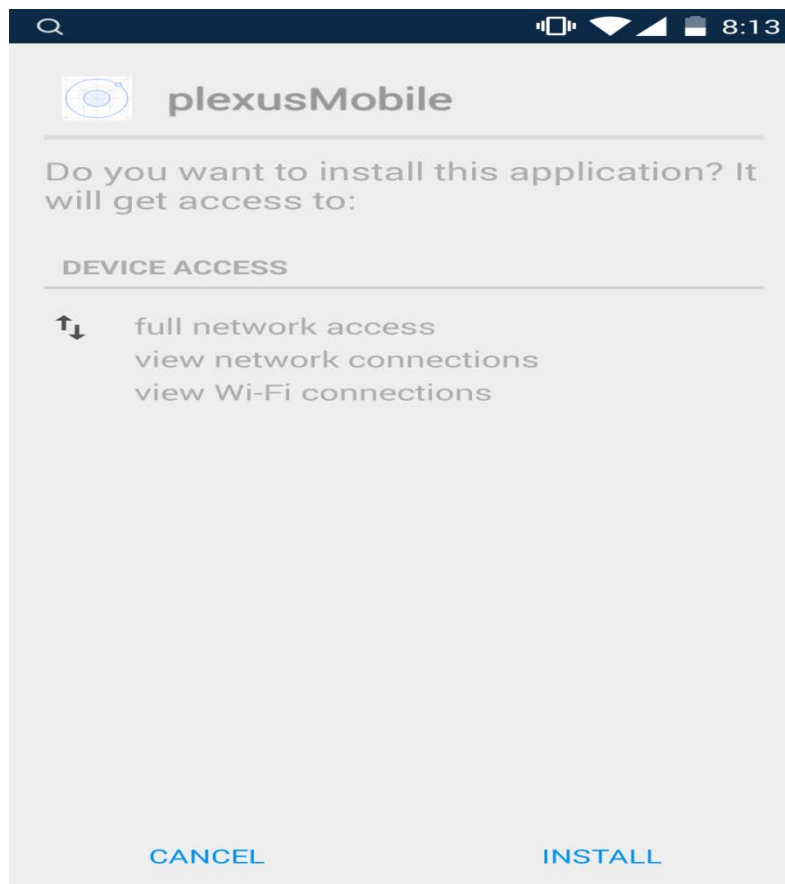


Figure 6.3.1: Application Download Page



Figure 6.3.2: Mobile Login Page

It is indeed a simple yet efficient login page where we can login with the existing user as saved in the database. It is same as our very own website where we can see that if proper information is not given then the user will not be able to login. We have limited our mobile application features for security purpose as there is no registration page. So, no fake person can access without having the required field information.

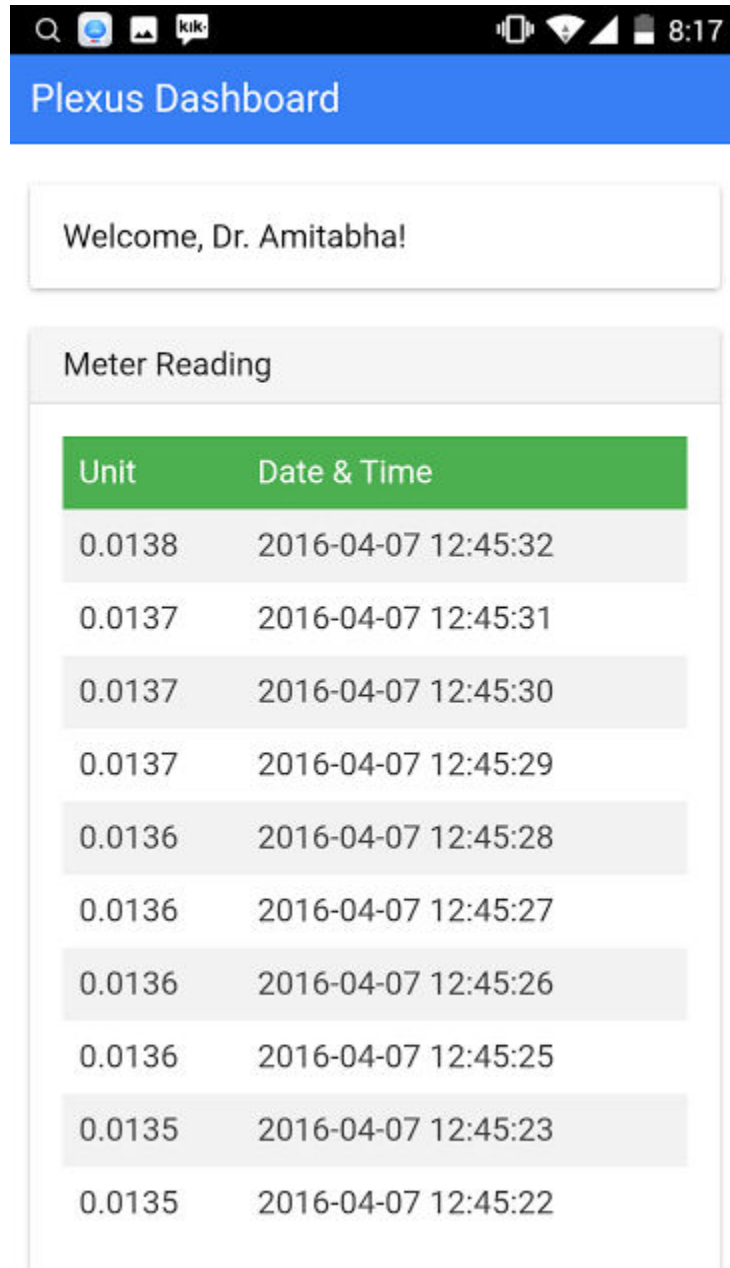


Figure 6.3.3: Mobile Plexus Meter Reading

The same data that is seen at the web is seen in the mobile based dashboard which is simple to see and easy to use. Meter reading is done where we can see the units with the date and time.

The screenshot shows a mobile application interface with a blue header labeled 'Plexus Dashboard'. Below the header is a section titled 'Billing records' containing a table with the following data:

Month	Unit	Amount	Status
March		-2.9709	Unpaid
March		-2.9586	Unpaid
March		-2.9583	Unpaid
March		406.06	Unpaid
March		6976.02	Unpaid
March		122.39	Unpaid
March		9.242	Unpaid
March		169.082	Unpaid
March		194.082	Unpaid
March		2570.19	Unpaid
March		2570.19	Unpaid
March		2570.19	Unpaid
March		22.76363985	Unpaid

Figure 6.3.4: Mobile Plexus Meter Reading (Billing Records)

Billing records are recorded here according to month and it shows the status of the bills which are “Paid” and “Unpaid”. Here some of the sample data are used. Both web and mobile applications are synchronized with mutual database which provides the exact information simultaneously over the two interfaces.

6.4 Hardware Calibration Analysis

We have already seen the analysis of the Website and Mobile application and how they work seamlessly time over time. Now let's take a dig into the main engine that is providing data to our databases. And that is our hardware (in this case the meter we have used). Our hardware parts have gone through immense trial and error to get this calibration we achieved in our thesis project.



Figure 6.4.1: Meter Calibration Accuracy

Over here we can see that some of the appliances are being used as our meter shows. In the left side of the Figure 6.4.1 we see a 16x2 LCD display from where we say conclude that some appliances are being used. If we look at the Wattage/hour: 0.09 which means at least 90Watt power is being consumed. The Ampere shows 1.45 which is accurate of the Clamp meter reading that we are seeing on the right hand side of the figure. So, calibration accuracy is achieved.

Chapter 7

CONCLUSION AND FUTURE WORKS

In order to sum up our complete work we have discussed over all everything that is required for the thesis report and concluded it in short. We have also said in brief about our future works that we would like to implement and take this thesis project to more advanced level.

7.1 Conclusion:

Day by day the single phase electronic meters are getting more advanced. They are coming up with high level of encrypted data and SPI communication with the console or a computer to verify the meter has not been tampered with. But wireless technology along with this the electronic meters has totally changed the dynamics of the whole outcome. The Internet around us is available and the package rates for Internet connection are standard hence it is very cheap to transfer this energy data. The very efficient & low costly transmission of energy values via this wireless technology through the help of Internet and a web based solution we have created can be done more frequently to a remote station. This helps to energy utilities to generate timely bills, better understand energy consumption, demand patterns, reduce meter failures more efficiently and manage fraud to reduce.

The main idea behind this project is to reduce time for reading the consumer meter, same is found at the end of completion. The total energy reading time is just delay provided to get logged to the Internet and access the data via Website or Mobile application. This can be minimized up to micro seconds or a few taps of mobile or keystrokes of keyboard. The reading of energy values & monitoring them is very less time consuming activity by this project.

The system developed is very accurate & effective. This system eliminates all disadvantages of serial communication. i. e. even though the circuit is not able to get the acknowledgement of the data transfer, it is not affecting system performance. There is a very low chance of missing any data as our data rate is done and updated in the database every second. Moreover, our database can handle terabytes of data concurrently without any real hassle. Even if there is load shedding

and the communication device (in our case we have used Raspberry Pi) is out of power, it will resume from the previous state as the power supply comes back. Human interface is minimum hence there is no possibility to manipulate reading. The hyper terminal data can be stored in pdf format. The same data can be used for analysis of consumption pattern. This system can be modified further for three phase by using latest SPI metering ICs which will provide more parameters. In future Automatic Power factor corrector circuit can be done using same circuit.

7.2 Future Works

The future scope of this whole project is large. For now we can think of implementing this model for three phases by using latest SPI metering ICs which will provide more parameters. Then we are also thinking to apply automatic power factor corrector circuit. Theoretically we have implemented MCP3008.8-channel 10-bit ADC with SPI interface with raspberry pi. But due to lack of time and available resource we could not implement it practically. Some appliances of MCP3008 are sensor interface, process control, data acquisition and battery operated systems. If integrated with Pi we can achieve a lot of things. It is basically used as we know raspberry pi does not provide analog input, so we can use this MCP 3008 for ADC conversion. At present we can control the device that is connected to our system. But, one of our very ambitious goals is to take it to the next level. Apply our system in the power grid, from where it can control the whole country. Though it will take a lot of resources and funding to get it done but we must not lose hope and go with the positive flow.

Bangladesh at present have prepaid meter available but it has failed to make an impact. Prepaid meter can follow energy consumption, understand demand patterns, regulate current flow but it lacks seamless communication with any database that our system provides. To make an impact in Bangladesh and implement this very resourceful project is our main plan for the future.

Chapter 8

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